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REORGANIZED SCIENCE CURRICULUM, 6A, SIXTH GRADE SUPPLEMENT.
MINNEAPOLIS SPECIAL SCHOOL DISTRICT NO. 1, MINN.

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DESCRIPTORS- *CURRICULUM DEVELOPMENT, *CURRICULUM, *CHEMISTRY, *ELEMENTARY SCHOOL SCIENCE, *GRADE 6, TEACHING GUIDES, ASTRONOMY, BIOLOGY, EARTH SCIENCE, INSTRUCTIONAL MATERIALS, PHYSICAL SCIENCES, SCIENCE COURSES, SCIENCE ACTIVITIES, MINNEAPOLIS, MINNESOTA,

THE NINTH IN A SERIES OF 17 VOLUMES, THIS VOLUME PROVIDES THE SIXTH GRADE TEACHER WITH A GUIDE TO THE REORGANIZED SCIENCE CURRICULUM OF THE MINNEAPOLIS PUBLIC SCHOOLS. THE MATERIALS ARE INTENDED TO BE AUGMENTED AND REVISED AS THE NEED ARISES. THE SIXTH GRADE SUPPLEMENT IS IN THREE VOLUMES. VOLUME 6A HAS A DETAILED OUTLINE OF THE SUBJECT MATTER FOR GRADE 6 IN EACH OF THE FOLLOWING MAJOR AREAS AROUND WHICH THE CURRICULUM IS DESIGNED--(1) THE EARTH, (2) LIVING THINGS, (3) ENERGY, AND (4) THE UNIVERSE. A CHART INDICATES GRADE CONTENT FOR THE ENTIRE K-12 PROGRAM. VOLUME 6A INCLUDES INTRODUCTORY MATERIAL AND SECTIONS CONCERNING (1) CONCEPTS, AND (2) RESOURCE UNITS, CHEMICAL ENERGY. VOLUME 6B CONTAINS A RESOURCE UNIT ON SPACE TRAVEL, AND VOLUME 6C CONTAINS RELATED SECTIONS FOR SIXTH GRADE MATERIALS ENTITLED (1) BIBLIOGRAPHY, BOOKS, (2) BIBLIOGRAPHY, FILMS, AND (3) EQUIPMENT AND SUPPLIES. (DH)

SCIENTIFIC APPROACH TO PROBLEM SOLVING

1. Observation--first-hand experiences and observation.
2. Definition of PROBLEM--ask questions, choose one for investigation.
3. Results of other investigators--read about problem, discuss it with interested friends and resource people, examine the written material.
4. Possible solutions--list all possible guesses.
5. Choosing the best solution (HYPOTHESIS)--pick the "best guess".
6. Testing the hypothesis--planning and carrying out EXPERIMENTS to determine its truth.
7. CONCLUSION of accepting or rejecting hypothesis--draw conclusion from experiments to determine acceptance or rejection of "best guess".
8. More extensive testing of hypothesis--experiment further to determine if hypothesis always holds true.
9. Stating the THEORY and publishing results--restate the hypothesis in light of the above experimentation, publish in professional journal.
10. Finding mathematical proof--do any measuring and mathematical calculations to develop proof of theory.
11. Statement of LAW or PRINCIPLE--if no one can find a mistake in the mathematical proof or develop a contrary proof, the theory becomes a law or principle

THE SIXTH GRADE SUPPLEMENT

to the

REORGANIZED SCIENCE CURRICULUM

Kindergarten Through Grade Twelve

(For Discussion Purposes Only)

MINNEAPOLIS PUBLIC SCHOOLS
special school district no. 1
Minneapolis, Minnesota

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December 1, 1964

FOREWORD

Long before that famous October fourth, 1957, when Sputnik I rocketed into orbit, the science teachers of the Minneapolis Public Schools eagerly began work on the reorganization of the science curriculum from kindergarten through grade twelve. This reorganized science curriculum was requested by our instructional staff and developed by representative members of that staff.

The citizen of today must be science literate in order to exercise adequately his duties of citizenship. The contribution of the scientist to our way of life is the methods which he uses to attack a problem and seek its solution. These methods are unique, but more important, they are very useful; they can be applied in the solution of the everyday problem by knowledgeable children at all ages and grade levels, and by adults in all walks of life. If these methods of science are to be learned by the youth of Minneapolis, they must be learned by attacking realistic problems inside and outside the classroom. This practice in the solving of work-a-day problems trains our young citizens to think for themselves in seeking new solutions to age-old problems of our civilization.

In the Minneapolis Public Schools we recognize that science is a very important part of the liberal arts general education which should be studied by all students. We are aware of our responsibility for instruction which must be well grounded in the fundamental laws and principles in all the fields of the basic sciences and therefore propose this reorganized curriculum for teaching the ever-expanding knowledge of science.

This reorganized science curriculum does not teach itself. It is a planned developmental approach in which the teacher is the expeditor and not the limiter of learning. The curriculum has been developed to aid the student in acquiring new breadths and new depths of understanding of his environment; and with it a teacher who is well trained in science may lead the student in an ever-expanding investigation of his surroundings in this world and universe. If the curriculum is used cooperatively by teacher and students, it is an instrument which can mold a pupil of the Minneapolis Public Schools into a science-literate citizen who, if he continues advanced science training, may become a scientist of the future.

Rufus A. Putnam
Superintendent of Schools

INTRODUCTION

This Supplement has been prepared as a convenient reference to assist the sixth grade teacher in teaching the science content allocated in the Reorganized Science Curriculum. Sixth grade teachers suggested and assisted with the preparation of each section of this Supplement. Those who have participated in the preparation of this Supplement lay no claim to its being "without blemish". However, its value can be determined only by those classroom teachers who use it and make constructive suggestions to improve it. All Minneapolis Public School personnel are invited to cooperate in improving this Supplement in order to make it of genuine assistance to all beginning and experienced sixth grade teachers. All constructive suggestions should be called in or sent to the Science Department Office.

This Supplement is not complete at the present time. When additional materials are developed, a copy will be furnished to you to place in this loose-leaf binder. Your cooperation with us to keep your Supplement up-to-date will be appreciated. When you leave your school, please leave the Supplement for the next teacher's use.

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

For discussion purposes only

SUMMARY OF GRADE-CONTENT ASSIGNMENTS

Area and Major Topics	Grade Level K	1	2	3	4	5	6	7	8	9	10	11	12
Introduction to Science (Gray)	*	*	*	+	*	*	*	+	+	+	+	+	+
A. Attitudes (Including history)	+	+	+	+	+	+	+	+		+			+
B. Tools	+		+	+	+		+		*				+
C. Methods	+		+	*	+	+	+			*			

	K	1	2	3	4	5	6	7	8	9	10	11	12
I. The Earth (Red)	+	+	+	*	*	+		+	*				
A. History of the earth					+				+				
B. Physical features	*	+		+	+				+				
C. Rocks and minerals	+	*			+				+				
D. Soils		+		+	+				+				
E. Water	*		*	+	*			*					
F. Air	+	*		+	*			*					
G. Weather and climate				+		*			*				

Key to symbols -- * major emphasis
+ content to be taught

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Area and Major Topics	K	1	2	3	4	5	6	7	8	9	10	11	12
II. Living Things (Green)	+	+	+	+	+	+		*			*		
A. Life and life processes	+	+	+	+		*		+			+		
1. Life in general	+			*		+		+			+		
2. Food taking or nutrition		*	*	+		+		+			+		
3. Digestion								+			+		
4. Absorption						+		+			+		
5. Circulation				+		+		+			+		
6. Respiration						+		+			+		
7. Assimilation								+			+		
8. Oxidation						+		+			+		
9. Excretion				+		+		+			+		
10. Reproduction and growth		*	*	*		+		+			+		
11. Responsiveness	+	*	+	+		+		+			+		
B. Classification	*	+	+	+		*		+			+		
C. Ecology	*	+	*	*	*			+			+		
D. Plant and Animal economics	+	+	+	*	*			+			+		
E. Human body	*	*	*	*		*		*			+		
F. Aesthetic values	*			*				+			+		

(continued)

Grade-content assignments (continued)

Area and Major Topics	K	1	2	3	4	5	6	7	8	9	10	11	12
III. Energy (Yellow)	+	+	+	+	+	+	+			+		*	+
A. Properties of matter related to energy	+			*			*			*		+	*
B. Sources and conservation of energy	+			+		*				+		+	+
C. Mechanical energy and simple machines	*		*	*			*			*		+	
D. Gravitational energy	+			+			+			+		+	
E. Magnetic energy	*		*	+	*					+		+	
F. Sound		*	*				*			+		+	
G. Electrical energy		*		*		*				*		*	
1. Static						+				+		+	
2. Current		*		*		+				*		+	
H. Communication bands and electronics												+	
I. Heat and Infrared radiation	*			*		*				+		+	
J. Light and Ultraviolet radiation	*	*	*				*			+		+	
K. High energy waves												+	
L. Chemical energy				+			*			*			*
M. Atomic energy							+			+		+	*

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Area and Major Topics	K	1	2	3	4	5	6	7	8	9	10	11	12
	Grade Level												
IV. The Universe (Blue)	+	+	+	+		*	+		*	+			
A. Earth	+	*	*	*		+			+				
B. Moon	*		*			+			+				
C. Sun	*	*	*	*		+			+				
D. Solar system						+			+				
E. Stars and galaxies	*		*	*		+			+				
F. Space Travel		+	+	+			*			*			

Key to symbols -- * major emphasis
+ content to be taught

Note: Conservation and safety must permeate science teaching at all grade levels.

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SUBJECT MATTER ALLOCATION

Grade Six

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SUBJECT MATTER ALLOCATION

Grade Six

Note: This report recommends an order of presentation of science content and summarizes the concepts found in the Handbook. The examples used to illustrate each item are intended to stimulate thought association and not to restrict the presentation of this material.

INTRODUCTION TO SCIENCE

Attitudes (including history)

importance of good mental attitudes for scientific investigation--open mindedness, intellectual honesty, creative imagination

value of scientific knowledge--improvement of man's health and welfare, increasing national prosperity

Tools

ways to improve accuracy of observation--use of mathematics, accurate instruments

Methods

relationship between cause and effect--laws of nature, scientific laws and principles

ENERGY

Properties of matter related to energy

states of matter--solid, liquid, gas

measurable characteristics of matter--density, size, specific gravity, buoyancy, mass, surface area, volume, elasticity, surface tension

conversion of matter to energy--radioactive atoms, fission, fusion

effects of heat on matter--expansion and contraction, melting, vaporization

basic and derived measurements of materials--weight, length, area, volume

Chemical energy

changes in state--states of matter, energy requirements

occurrence and composition of materials--part of all environments, all matter

chemical changes--putting elements together, new substances; compounds, molecules

chemical shorthand--symbols, formulas

simple reactions of oxygen--burning, rusting, needed to support life

characteristics and uses of fuels--kindling temperature, stored chemical energy

characteristics of atoms and molecules--in motion, invisible

Mechanical energy and simple machines

basic principles and construction of simple machines--six types of simple machines (lever, wheel and axle, pulley, inclined plane, screw, wedge); relation of load to effort

uses of machines--convert energy to work; change in force, speed or direction

compound machines--made of simple machines

uses of gears, belts and chains to transfer energy and to do work--gear ratio

effects of friction; methods of changing the amount of friction--decreased efficiency of machines, lubrication

Sound

sources of sound--vibrating strings, cords, diaphragms, reeds, and air columns; chemical change

differences in detection of sound by living things--loudness, pitch; viriation among living things, organ for detection of sound

speed of transmission and absorption of sound--wave characteristics, conducting mediums

reflection of sound--reflecting surfaces, echos

characteristics of sound wave patterns--music versus noise

Light and ultraviolet radiation

sources and speed of light--direct or reflected light, natural and artifical light, fire, incandescence

transmission of light through space--radiant energy, speed of light, amount of sun's light reaching earth

reflection, refraction and transmission of light by various materials--lenses, mirror, shadows, prism

dispersion of white light--visible spectrum, composition of white light

relation of colors to light properties--reflected light, emitted light

THE UNIVERSE

Space travel (includes some aviation, space biology, gravitational energy, and mechanical energy)

- problems associated with providing a safe environment in space--need for oxygen, protection from sun's energy

- adaptations to changed environment--weightlessness

- structural strength and equipment necessary for a space vehicle--resistance to heat and stress, need for new materials and new instrumentation, bombardment by meteors, guidance equipment

- thrust requirements--rocket engines, gravity, inertia

- mutual attraction of objects in space--moon and earth, rocket and earth, attraction related to mass and distance, retro-rockets

- effects of air on moving objects--friction, heat

- need for new methods of telling time and measuring distance

- motivation for exploration of space--expanding knowledge

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Grade Six

ALLOCATION OF CONCEPTS BY MAJOR TOPICS

Note: This report recommends an order of presentation of science content at each grade level and changes the order of the concepts found in the Handbook to provide a logical teaching approach.

Fall

Introduction to Science

For this unit it might be helpful to review the concepts taught under the topic of "Introduction to Science," in grade four.

A. Attitudes (including history)

1. Creative scientific work involves an open mind and willingness to change.

2. Great scientists have the following personal characteristics: an inquiring mind, ability to observe accurately, a creative imagination, patience, perseverance, and intellectual honesty.

3. The amount of scientific information is increasing more and more rapidly.

4. Application of scientific knowledge contributes to man's health and welfare.

5. The application of science principles contributes to the prosperity of our nation.

6. Expanding knowledge of environment increases man's ability to control it.

B. Tools

1. Some special kinds of equipment and supplies may be necessary to carry on certain kinds of experimentation.

2. Facilities for scientific investigations should include adequate and properly maintained space, equipment, and supplies.

3. More accurate instruments are developed as scientists search for truth.

4. A quantitative approach to a scientific problem requires measurement and calculation, which involve the use of mathematics.

5. Different mathematical systems of measurement are useful to scientists.

C. Methods

1. The methods of science include observation, classification, and organization of facts and the development of verifiable laws and principles.

2. Many science problems originate as questions about cause and effect relationships.

3. Critical and creative thinking are necessary in deducing cause and effect relationships during scientific investigations.

4. Scientists attempt to discover, measure, and express the laws of nature.

5. Very early during the process of seeking a solution to a problem in science, a careful search should be made for the published and unpublished investigations of other scientists.

Fall and Winter

III. Energy

A. Properties of matter related to energy.

1. Odor, taste, and irregular shapes are some descriptive properties of matter that cannot be measured.
2. Many physical properties of a substance are measurable.
3. Weight is measured as a characteristic of a quantity of a substance.
4. All substances of the same size do not have the same weight.
5. The weight of many substances is compared with the weight of an equal volume of water (specific gravity).
6. All objects seem to lose some weight when floating or submerged in water.
7. The standard for measuring mass in the English System is the pound.
8. Length is the distance between two points.
9. The amount of surface anything covers is called area.
10. Area is the sum of the number of unit squares that a surface contains.
11. Volume is the means of expressing how much space a substance occupies.
12. Volume is the number of cubes of a given unit that a substance contains.
13. When a substance is heated, it usually expands.
14. Gases tend to expand when heated and contract when cooled.
15. The volume of a gas changes with each change of temperature and/or pressure.
16. A gas uniformly distributes itself throughout a closed container.
17. Cooling makes many solids, liquids and gases contract.
18. Different solids have different melting points.
19. Different liquids have different freezing points.
20. Most gases may be changed to a liquid.

21. Most solids, liquids and gases expand when they are heated.

22. Most substances expand when heated and contract when cooled.

23. Most liquids may be changed to gases.

24. The more a liquid is heated, the faster it evaporates.

25. When most liquids evaporate a solid material is left behind.

26. Water may contain many impurities.

27. Heat energy always is involved in the change of state of a substance.

28. A solid may have a definite size and shape.

29. Different materials conduct heat at different rates.

30. Objects which bump together often bounce apart.

31. Some objects which bump together do not bounce apart.

32. Twisting tends to shorten materials.

33. Energy is very often stored in coiled springs by twisting them.

34. Liquids "climb up" surfaces which they wet.

35. Surface tension of a soap solution is less than that of water.

36. Soap and most materials which dissolve in water reduce its surface tension.

37. Surface tension of a liquid may be explained by the unbalanced forces of attraction between like molecules.

38. A substance may be an element, a compound or a mixture.

39. Elements, compounds and mixtures may exist as gases, liquids, or solids.

40. A few mixtures may be separated easily into the components.

41. An atom cannot be seen even with the best kind of magnifier now known.

42. The atom contains great amounts of energy.

43. Small amounts of matter can be converted to great amounts of energy.

44. The breaking up of an atom releases great amounts of energy.

45. Radioactive disintegration may be controlled.

46. Most radioactive materials are dangerous.

47. A Geiger counter is a device often used to detect the presence of radioactive particles.

L. Chemical energy

1. Chemical energy is one form of energy.

2. Chemical substances may be found many places in the environment.

3. All materials are chemical substances.

4. Many chemical substances are helpful or harmful to living and non-living things.

5. Man has never seen an atom.

6. Two or more different elements may be combined to form compounds which have definite properties.

7. Atoms may be combined to form molecules.

8. A molecule usually contains two or more atoms.

9. All substances are composed of one or more elements.

10. The chemical behavior of materials may be observed and studied any place in our environment.

11. A chemical change in substances forms different substances.

12. Some chemical changes may be used to produce heat, light, or electrical energy.

13. An atom is always in motion.

14. The molecules of a substance are always in motion.

15. All matter exists as solid, liquid or gas at room temperature.

16. Energy is required to change the state or motion of matter.

17. Many kinds of matter can be changed from one state to another.

18. Two portions of matter cannot occupy the same space at the same time.

19. The air is a mixture of gases.

20. Nitrogen is the most plentiful gas in our atmosphere.

21. Oxygen is needed to support life.

22. Oxygen readily combines with many substances.

23. Oxygen combines with many substances to give off heat.

24. Oxygen is needed for combustion.

25. The burning of fuel, which is a chemical change, releases energy.

26. Oxidation is the process in which substances combine with oxygen.

27. Oxidation may be fast as in the burning of a fuel or slow as in the formation of rust.

28. The energy of chemical oxidation may be released as heat, light or electrical energy.

29. All living things contain carbon.

30. All common fuels contain carbon.

31. Different fuels have different kindling temperatures.

32. Fossil fuels and plant foods contain stored chemical energy.

33. Most of the stored energy on earth comes indirectly from the sun.

34. The study of chemistry has resulted in development of a "language" and shorthand with which to express ideas.

C. Mechanical energy and simple machines

1. Man is learning to move energy from its source to the place where it is to be used.

2. A machine usually is the device that changes energy to work.

3. Machines do not create energy.

4. A machine may be used to increase force.

5. A simple machine may change the amount of force applied to overcome a resistance.

6. A simple machine may change the direction in which a force moves a resistance.

7. A simple machine may change the speed at which a resistance may be moved.

8. A wedge is a type of inclined plane machine.

9. A wedge may be used to push things apart.

10. A longer inclined plane requirod less effort to move a resistance to the same height.

11. A screw is an inclined plane wrapped around a cylinder.

12. A fixed pulley may be used to change the direction of force.

13. A fixed pulley is a wheel that turns on a stationary axle.

14. A lever moves about its fulcrum.

15. Levers are used to apply a force which can exert a push, pull, pry and twist.

16. The closer the relative distance of the load to the fulcrum as compared to the distance of the effort to the fulcrum, the less effort is needed to move the resistance.

17. In a lever the further the distance of the resistance to the fulcrum as compared to the distance of the effort to the fulcrum, the faster the resistance may be moved with a given effort.

18. Two or more simple machines are connected to make a complex or compound machine.

19. Compound machines are combinations of simple machines.

20. A complex machine may change one kind of energy into another.

21. A machine usually makes more efficient use of applied energy when friction is reduced.

22. Friction is a force that resists other forces.

23. All forces opposing motion are called friction.

24. Friction is the resistance to relative motion of two objects in contact.

25. The friction of molecules of a liquid as they move one over the other is less than sliding friction between two surfaces.

26. Friction between two surfaces may be reduced by using smoother surfaces or by the introduction of a liquid between the surfaces.

27. Rolling friction as used in rollers and wheels is less than sliding friction.

28. Ball bearings are used to decrease friction in any direction.

29. Friction may be reduced by smoothing the surfaces in contact.

30. Some devices depend on friction for their operation.

31. Belts, chains and gears are used in machines to transfer force from one wheel to another.

32. A big gear turning slowly makes a little gear turn rapidly.

33. In meshing gears the following proportion is always true: the number of turns of the little gear is to the number of turns of the large gear, as the number of teeth on the large gear is to the number of teeth on the small gear.

34. Things that are not in motion tend to remain at rest.

35. Once something has started to move, it may keep moving.

36. For each action there is an equal and opposite reaction.

37. The pendulum may be used to demonstrate periodic motion.

38. Aircraft may be of many different kinds.

39. Powered aircraft may be of many different kinds.

F. Sound

1. Different kinds of animals vary in their ability to detect sounds.
2. Different kinds of animals differ in the loudness or softness of sounds they can detect.
3. Different kinds of animals may have different abilities to detect high or low sounds.
4. Some different kinds of animals vary greatly from one another in the mechanical methods by which they detect sound.
5. The ear is the organ which higher animals use to detect sound.
6. Hearing involves receiving, transmitting, and interpreting of sound waves by the ear, auditory nerve, and brain.
7. The ability to hear sounds differs with people.
8. Low-pitched sounds (under 16 vibrations per second) are usually inaudible.
9. Very high pitched vibrations are inaudible.
10. High pitched vibrations (ultrasonics) have uses.
11. Some characteristics of sounds are pitch, loudness and quality.
12. Sound travels in waves.
13. Some materials are better conductors of sound waves than others.
14. Sound may be transferred from one substance to another.
15. Sound can travel through gases, liquids and solids.
16. Some materials absorb sound waves better than others.
17. Various materials may be used to record and reproduce sound impulses.
18. Soft surfaces absorb more sound than hard surfaces.
19. Porous and spongy surfaces are good sound absorbers.
20. Hard surfaces reflect more sound than soft surfaces.
21. A reflected sound which is similar but distinctly different from the original sound is an echo.
22. Echos require a distance surface or denser medium for the reflection of the original sound.

23. A megaphone may be used to direct sound.

24. Sound waves may be directed by a reflector.

25. The sudden releasing of heat energy causes an explosive sound.

26. Speech is produced by the controlled vibration of vocal cords.

27. Some mechanical devices produce a sound which is called music.

28. Music is the uniform, regular repetition of a regular sound wave pattern.

29. Musical instruments use vibrating strings, reeds, diaphragms, and air columns to produce music.

30. Changing the length, thickness, density, or tension of a vibrating string changes its pitch (vps).

31. Each different pitch produced by a musical instrument is called a tone.

32. The quality of the tones produced by a musical instrument depends upon the structure of instrument and how it is played.

33. Constant noise increases fatigue.

J. Light and ultraviolet radiation

1. The sun has different kinds of energy.

2. Light is a form of radiant energy.

3. The sources of light on the earth are direct or reflected.

4. Direct sources of light on the earth are natural (sun, stars) and artificial (incandescent, fluorescent).

5. Indirect sources of light on the earth include the moon, planets, dust particles of the atmosphere, and objects on the surface of the earth.

6. An eclipse of the moon is observed on the earth when the earth prevents the light of the sun from falling upon the moon.

7. Light travels through space by radiation.

8. Light travels at extremely high speeds.

9. Movements and changes in objects in outer space are observed some time after their occurrence.

10. The light which reaches us from the sun comes directly by radiation or indirectly when refracted from other astronomical bodies.

11. Most of the sun's energy is lost in space.

12. Only a small part of the sun's energy reaches the earth.

13. The angle at which the sun's light strikes the earth affects the amount of heat received in a given surface area.

14. Types of interior lighting may be direct, indirect or semi-direct.

15. Sunlight is a combination of many colors.

16. Light can be separated into a band of colored light.

17. When all the colors of light are put together, white light is produced.

18. White light is made of red, orange, yellow, green, blue, and violet light waves.

19. Sometimes light that travels through transparent objects is bent (refracted).

20. A prism is a device usually with a triangular shape which separates white light into bands of colored light (spectrum).

21. Drops of water in the air act like prisms and disperse white light into the many colors of the rainbow.

22. A color of an object is determined by the light rays which it reflects or emits.

23. Black is the absence of reflected light.

24. A black object absorbs all colors of light.

25. Some light passes through translucent materials, but objects cannot be seen distinctly through them and may not be visible at all.

26. Smooth, highly polished objects are good reflectors of light.

27. Images appears to be as far behind a plane mirror as objects are in front.

28. Light reflected from an object makes the object visible.

29. When light is scattered by irregular reflection, it is said to be diffused.

30. Objects become visible only by diffused reflection.

31. Light cannot pass through opaque objects.

32. The size of the shadow of a standing object depends upon the position of the sun or other light source.

33. A shadow has three dimensions.

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Spring

IV. The Universe

F. Space travel
(includes some aviation, space biology, gravitational energy and mechanical energy)

General

1. Through space travel man will discover many new things about the universe.

2. Man's existence on the earth is limited to the surface or near the surface.

3. There is less air as one moves up (or out) from the earth.

4. Space is dark (beyond the atmosphere).

5. Artificial satellites are being used by man to further his study of earth and space.

6. Anything within the solar system is known as being in interplanetary space.

7. Man is beginning to travel up or "out" into interplanetary space.

8. Anything beyond the solar system is known as being in outer space.

9. There is a very slight amount of air in outer space.

10. Nearness and farness in comparing bodies in space is relative.

11. Great distances in the universe are measured in terms of light-years, the distance which light travels in one year.

12. Units of time in space may be measured differently from the units of time on earth.

13. There are many problems which must be studied and solved before man can travel for extended periods of time in space.

14. There is great need for trained people to study the problems of space travel.

15. As more is learned about space travel, other factors may be found which may limit man's existence in space.

16. New projects related to space travel are continually being developed and evaluated in order to expand upon existing knowledge.

17. Results from one experiment in space research lead to the formulation of many other problems for study.

18. Problems in the building of space travel devices require the development of many new materials.

Properties of Space -- Universal Gravitation

19. Objects close to an astronomical body in space are attracted to that body.

20. In outer space, the pull of the earth would be very slight.

21. Many natural phenomena result from the pull of the earth; e.g., weight, water running downhill.

22. Weight is an important factor when planning a rocket's escape from the earth's gravity.

23. To get into interplanetary space a rocket must "push" harder than the earth pulls.

24. The harder a rocket "pushes" away from the earth, the farther it can go before it begins to fall.

25. A rocket which "pushes" hard enough can go farther than the distance beyond which the earth can pull it back.

26. It is possible to place objects out into space by starting them with enough force and speed to escape the gravity of the earth.

27. In order for an object to escape the gravity of the earth, it must reach a greater speed than that required to orbit the earth.

28. Gravity decreases as one leaves the earth, but increases as one approaches other astronomical bodies.

29. The moon "pulls" on things on the earth.

30. The gravitational pull on surface objects is greater on the earth than on the moon.

31. The closer an object is to the moon, the greater is the mutual attraction.

32. As two objects approach each other, the greater is the mutual attraction.

33. Gravitational energy is opposed with parachutes.

34. When approaching the earth, rockets and/or parachutes must be used to work against the earth's gravity to slow down the vehicle and thus prevent destructive impact.

35. To insure a safe landing on any astronomical body, the space vehicle would have to use a force against gravity to slow its descent.

Properties of Space--Near the Earth (Atmosphere)

36. Air resists the force which would put an object in motion.

37. The resistance caused by air moving over an object is called air friction.

38. An object moving through air produces air friction.

39. The density (concentration) of air affects the amount of friction.

40. The density of the earth's atmosphere decreases as the distance from the earth increases.

41. As the speed of a moving object increases in the atmosphere, friction and heat increase.

42. Speed and altitude both determine the amount of friction on space vehicles.

43. The greater the air friction, the more intense the resultant heat.

44. Certain designs reduce friction.

Problems of Man's Existence in Space

45. Man must be protected during space travel.

46. Man cannot exist in space without controlling his immediate environment.

47. Vehicles for space travel must provide a desirable environment for man.

48. Man is able to adapt to a slightly changed environment.

49. Man can live for a short period of time in a greatly changed environment.

50. Man has to carry his own oxygen when traveling away from the earth.

51. Due to weightlessness in space travel, man may have problems with his breathing, drinking, eating and moving.

52. Sustained weightlessness may cause many hazardous strains on the human anatomy.

53. The radiant energy from the sun may be dangerous to a man in interplanetary space.

54. Man will have to establish an artificial environment in order to survive on the surface of other astronomical bodies.

Problems of Movement in Space

55. Space vehicles need to be protected against bombardment by meteors and cosmic dust.

56. Rockets must be made of materials which withstand heat and stress.

57. A rocket begins to rise very slowly because of the forces which must be overcome; e.g., inertia.

58. Space ships require many instruments to guide them.

59. High speed in space travel is desirable to cover great distances in a convenient time.

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A RESOURCE UNIT

III. ENERGY

L. CHEMICAL ENERGY

TO BE TAUGHT IN

GRADE SIX

To be included in the Grade Six Supplement of the Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
8-24-64

For discussion purposes only

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For discussion purposes only

VI. Learning Activities:

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I. INTRODUCTION

This unit gives sixth grade children an opportunity to explore some of the basic ideas and understandings in the world of chemistry using many types of learning situations and problem solving techniques. This unit suggests the use of common materials and the exploration of problems involving some of the chemistry in daily life. Through the study of this unit the children should arrive at an understanding of some of the fundamental principles and laws of chemistry and gain some elementary understandings of the structure of matter.

While the main objective is a rudimentary understanding of chemistry and chemical energy, there are other objectives which may be actively pursued in this unit. A unit of this type affords an excellent opportunity for the development of an understanding of the experimental approach to science and emphasizes the importance of accuracy in planning, observing and expressing conclusions based on the results of experiments and demonstrations.

Although an extensive write-up of each activity is not recommended, the teacher should require the children to keep careful records of their observations, analyze their collected information, and write reports for a few of the quantitative activities. To avoid excessive paper work, a written report of an activity might be limited to answering the following questions: "What equipment did we use?" "What did we do?" "What did we learn?" "What else do we want to know?" Further, a unit on chemical energy aids in the development of skills, in the safe handling of materials and in the formation of safe habits of experimental procedure.

The teacher is urged to spend some time before beginning the unit in teaching the children the importance of following all safety rules and observing all general precautions. Throughout the entire unit, stress should be placed on safety. In using the material of this resource unit, caution must be exercised to prevent accidents. All, especially dangerous experiences have been removed from this resource unit. However, none of these learning activities should be used with the pupils for the first time unless the teacher himself has tried them out thoroughly before class use.

This resource unit does not need to be taught in its entirety; rather, each individual teacher should select from the resource unit those learning experiences which would be most useful in developing the teacher's own teaching unit to be used within his own classroom for his own pupils. However, an orderly sequence of learning activities is desirable rather than a random presentation of learning situations, since an adequate understanding of many of these concepts depends on learning activities which may have been developed earlier in the unit.

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The chemical energy concepts which are appropriate to the sixth grade level have been arranged in a logical teaching order in Section II. Since the activities suggested in this resource unit are not correlated directly to the individual concepts, the classroom teacher should periodically check the list of concepts to be sure that none of the concepts are omitted.

Although some classes, groups or individuals may wish to explore some of the concepts in greater depth than this resource unit provides, the resource unit should assist the teacher in planning his own basic teaching unit which gives the average sixth grader a broader view of this area of science. The children should begin to understand "chemistry" as a slowly evolving field of science rather than a body of knowledge which developed in a brief period of time.

Although some children may rush to study the periodic chart as a part of an individual project, the periodic chart should not be studied formally during the unit. At this grade level awareness that there is a possible grouping of the similar elements and that symbols may be used to briefly present detailed information is probably the most important understanding that should be taught.

The degree to which this unit stimulates curiosity and interest, leading to a desire for further observation and study of the natural chemical environment is a good measure of its value and the teacher's success in teaching this unit.

II. CONCEPTS INCLUDED IN THIS UNIT

L. Chemical energy

1. Chemical energy is one form of energy.
2. Chemical substances may be found many places in the environment.
3. The chemical behavior of materials may be observed and studied any place in our environment.
4. All materials are chemical substances.
5. Many chemical substances are helpful or harmful to living and non-living things.
6. Man has never seen an atom.
7. Two or more different elements may be combined to form compounds which have definite properties.
8. Atoms may be combined to form molecules.
9. A molecule usually contains two or more atoms.
10. All substances are composed of one or more elements.
11. During physical changes only physical characteristics may change.
12. A physical change in a substance does not form any different substance or substances.
13. A chemical change in substances forms different substances.
14. Some chemical changes may be used to produce heat, light, or electrical energy.
15. An atom is always in motion.
16. The molecules of a substance are always in motion.
17. All matter exists as solid, liquid or gas at room temperature.
18. A physical change in a substance requires energy.
19. Energy is required to change the state or motion of matter.
20. Many kinds of matter can be changed from one state to another.
21. The air is a mixture of gases.
22. Nitrogen is the most plentiful gas in our atmosphere.

23. Oxygen is needed to support life.

24. Oxygen readily combines with many substances.

25. Oxygen combines with many substances to give off heat.

26. Oxygen is needed for combustion.

27. The burning of fuel, which is a chemical change, releases energy.

28. Oxidation is the process in which substances combine with oxygen.

29. Oxidation may be fast as in the burning of a fuel or slow as in the formation of rust.

30. The energy of chemical oxidation may be released as heat, light or electrical energy.

31. All living things contain carbon.

32. All common fuels contain carbon.

33. Different fuels have different kindling temperatures.

34. Fossil fuels and plant foods contain stored chemical energy.

35. Most of the stored energy on earth comes indirectly from the sun.

36. The study of chemistry has resulted in development of a "language" and shorthand with which to express ideas.

III. SAFETY RULES

Materials needed:

Fire extinguisher
Fire blanket
Emergency Care Chart (prepared by the Department of Health, Physical Education and Recreation, Minneapolis Public Schools)

First aid kit

1. Keep the materials needed in an easily accessible place in the classroom during many of these learning activities. Safety first.
2. Never mix "just any" chemicals except when following specific instructions.
3. Never heat any chemical except when following specific instructions.
4. Never taste any chemical unless absolutely sure it is not poisonous.
5. Never smell any chemical unless absolutely sure it is not poisonous.
6. Never allow any chemical to come in contact with the skin unless absolutely sure it is not poisonous or printed instructions direct it.
7. Never lean over the flame of a liquid petroleum burner or any other heat source.
8. Extinguish all open flames when no longer in use.
9. Girls should put up long hair and fasten up flowing sleeves.
10. Never light a match or a burner near an open container of chemicals.
11. Label all flammable and/or explosive materials. Keep them away under lock except when using.
12. Lubricate the outside of the end of glass tubing with a few drops of glycerine before attempting to push the glass tube through a cork or rubber stopper. Wrap a cloth towel around the tubing to protect the hands in case of breakage during the procedure.
13. Allow enough time for hot objects to cool completely before touching them.

IV. PRECAUTIONARY AND GENERAL LABORATORY SUGGESTIONS

(It is recommended that at least one lesson be devoted to precautionary and general laboratory suggestions before beginning a teaching unit in chemical energy.)

A. Fires

The location and operation of the nearest fire extinguisher and fire alarm must be taught to the children before any of the burning activities are attempted. It is important that the children know how to remove the extinguisher from the wall, how to remove the locking pin, and how to aim and use the extinguisher. Very small accidental fires may be smothered with an asbestos mat. Caution the children not to run but rather to lie down and roll on the floor when their hair or clothing accidentally catches fire. The children should be trained to quickly wrap a heavy coat or some similar material around and over a child whose hair or clothing is burning. The user is required to always extinguish his lighted match and burning wood splint in a jar or can of water and to immediately place the extinguished match or wood splint in the wastebasket or a convenient waste can. The classroom teacher should refer to the booklet, Procedures for the Program of Fire Safety in the Minneapolis Public Schools, "E. General Fire Safety," sections 8 and 9, pages 9 and 10, for a statement of policy regarding the use of sources of heat in science experiments:

"8. The only exception to the rule relative to the use of candles is that in the elementary schools candles or other low heat types of fire may be used in science experiments if under strict supervision of the teacher, who should see that every precaution for safety is maintained during the lesson.

9. For science experiments in the elementary schools, self-contained liquid petroleum burners which are approved by the following may be used:
   a. United States Bureau of Statistics.
   b. Interstate Commerce Commission.
   c. Underwriters Laboratories.

   Rules which must be followed in this use are:
   a. This must be done under strict supervision of teacher.
   b. There shall be no more than four of these burners in a school building.
   c. There shall be a fire extinguisher available within twenty feet."

The teacher, children and the principal should discuss the fire ordinances which are also included in the fire safety booklet mentioned above.

B. Chemical poisons

Assume all chemicals are poisonous to humans. Do not taste, smell or touch any chemicals unless printed instructions indicate that it is necessary. Never drink from the laboratory glassware.

If the instructions for an activity suggest smelling a chemical substance, use a hand to scoop some air (wafting) from near the mouth of the bottle or Pyrex test tube towards the nose. If accidentally a chemical comes in contact with the skin, wash the skin immediately with a large quantity of water unless absolutely sure it is not harmful (i.e. common table salt). Make every effort to avoid spilling chemicals. If an accident does occur in which a chemical is spilled, wash away or mop up the spilled chemical immediately. In this unit some of the learning activities are specifically labeled "Teacher Demonstration" because of the dangerous nature of the chemicals involved. To learn the first aid procedures for chemical poisons, refer to the Emergency Care Chart posted on the wall of the classroom.

C. Equipment requirements

The suggestions made in the learning activities concerning the size or quantity of materials to be used may be modified to fit the kind of equipment available. However, do not try to "make do" with inadequate equipment. For example, do not use a handkerchief in place of a test tube holder to grasp hot objects. In recommending the equipment for use in each activity, the judgment of the classroom teachers has been used. Since a liquid petroleum burner provides adequate heat more quickly than an alcohol lamp, the liquid petroleum burner is recommended in certain activities. When a moderate amount of heat is required, an alcohol lamp is recommended. Use an asbestos pad on the table top under each burner. Because ordinary glass breaks easily when heated rapidly, Pyrex glass is recommended for those activities in which the glassware must be heated or chilled. Remember, however, that hot glass breaks if cooled quickly.

D. Good laboratory procedures

The equipment used in any activity should be cleaned and put away as soon as the activity has been completed. If glassware is broken, the broken glass should be cleaned up and disposed of immediately. Since chemical action and burns caused by hot objects usually mar the valuable surfaces of the furniture, the work should be done over an expendable surface such as a piece of unfinished lumber or better yet, a non-combustible surface such as an asbestos pad. Keep a jar or can of water handy in which to cool hot objects and extinguish burning matches and splints.

V. LABORATORY TECHNIQUES

In order to avoid being redundant and since many procedures are used repeatedly throughout this unit, the author does not include the list of the materials and instructions for the following laboratory techniques which are used throughout the learning activities. Please become familiar with these procedures.

1. Lighting an alcohol lamp

Materials needed:

Match
Jar or can of water
Alcohol, denatured
Wastebasket or waste can
Alcohol lamp

What to do:

1. Make sure the lower end of the wick is immersed in the alcohol. Have the teacher add alcohol to the lamp if necessary. Do not fill the lamp more than one-quarter full.
2. Light the match.
3. Remove the cap to the wick and light the lamp.
4. Extinguish the match in a jar of water and place it in a waste basket.
5. Extinguish the lamp when finished by replacing the cap.

2. Lighting a liquid petroleum burner*

Materials needed:

Match
Jar or can of water
Liquid petroleum burner
Wastebasket or waste can

What to do:

1. Light the match.

2. Hold it beside the top of the burner.

3. Turn on the gas by turning the valve. Do not remove the match until the burner is lighted.

4. Extinguish the match in a jar of water and place it in the wastebasket.

5. Extinguish the burner by turning off the gas.

* If the school is equipped with Bunsen burners, they should be used rather than the liquid petroleum burner.

3. Bending glass tubing

Materials needed:

Asbestos mat
Liquid petroleum burner
Wing top
Glass tubing (soft or lime)

What to do:

1. Fit the wing top onto the top of the burner.
2. Light the wing top of the burner.
3. Hold the ends of the tubing so that the tubing may be rolled between the thumb and the middle finger of each hand. Do not use too short a piece of glass.
4. Hold the tubing in the flame at the place where the bend is desired so that the greatest possible length of the tubing is heated.
5. Turn the tubing slowly by rolling it back and forth between the thumb and finger.
6. Heat the glass until the tubing begins to sag of its own weight.
7. Take the tubing out of the flame and bend it quickly to the angle desired.
8. Hold it in that position until the glass cools enough to harden again.
9. Do not set the glass down on anything except the asbestos mat until it is cooled and is at room temperature.
10. Extinguish the burner.

4. Cutting glass tubing or glass rod

Materials needed:

Triangular file
Glass tubing or glass rod

What to do:

1. Lay the tubing on a flat surface.

2. Hold a triangular file with the flat side up.

3. Rest the V shaped edge on the tubing at the place to be cut.

4. Place the index finger of the hand that is holding the file on the upper, flat side of the file.

5. Hold the glass tubing firmly in place with the other hand. Scratch the tubing by pushing the file with firm pressure across the tubing once, at right angles to the tubing at the location where the cut is desired. Put the file aside.

6. Wrap the four fingers of each hand around the tubing as close to the scratch as possible.

7. Rotate the tubing until both thumbs are on the side of the tubing just opposite the scratch so that the thumb nails meet opposite the scratch.

8. Pull gently with all fingers and push forward with the thumbs to bend the glass tubing. (Note: the glass tubing breaks quite easily.)

5. Smoothing the ends of glass tubing or glass rod by fire polishing

<u>Materials needed:</u>

Liquid petroleum burner
Match
Glass tubing or glass rod
Asbestos mat

<u>What to do:</u>

1. Light the burner.
2. Grasp the middle of the glass tubing between the thumb and middle finger of one hand.
3. Hold the tubing at a slant with one end of the tubing in the hot part of the flame.
4. Turn the tubing slowly.
5. Continue heating until the end of the tubing turns red.
6. Lay the hot end of the tubing on the asbestos mat. Allow to cool.
7. Extinguish the burner.

6. Making a stirring rod

Materials needed:

Glass rod
Triangular file
Liquid petroleum burner
Asbestos mat

What to do:

1. Cut the glass rod to the desired length.
2. Light the burner.
3. Heat one end slowly to fire polish it.
4. Lay the hot glass rod on the asbestos mat and allow it to cool.
5. Heat the other end slowly to fire polish it.
6. Lay the hot glass rod on the asbestos mat and allow it to cool.
7. Extinguish the burner.

7. Sealing glass tubing

Materials needed:

Liquid petroleum burner
Asbestos mat
Glass tubing

What to do:

1. Light the burner.
2. Grasp both ends of the tubing and hold the center portion over the flame.
3. Turn the tubing between the thumb and middle finger of each hand.
4. Heat until the glass sags of its own weight.
5. Pull slowly on both ends of the tubing while it is still in the heat.
6. Continue heating for a brief period of time after the two halves of the tubing have parted.
7. Allow to cool. Do not lay the pieces of tubing on anything except the asbestos mat until they are cool.
8. Extinguish the burner.

8. Inserting glass tubing through a cork or a rubber stopper

Materials needed:

Glycerine *
Towel, cloth
Cork or rubber stopper, which has a hole that is a size to fit the glass tubing and has an outside diameter to fit the flask or test tube as required by the activity
Glass tubing, (6 mm outside diameter or size to fit hole in stopper)

What to do:

1. Lubricate the outside of the tubing with glycerine at the end which is to be inserted into the stopper.

2. Wrap the cloth towel around the tubing. Grasp the towel and tubing near the end going into the stopper.

3. Push gently, and twist the tubing and stopper slightly in opposite directions. Do not push on a bend in the tubing or at a distance from the stopper. Push on bent tubing only along the length between the bend and the stopper.

4. Continue pushing by short grips and twisting movements until the glass extends through the stopper the desired distance.

* The use of water as a lubricant is less satisfactory. Soap may be a satisfactory lubricant in most cases.

9. Transferring small amounts of solid chemicals without contaminating them

Materials needed:

Solid chemicals in containers (jar, bottle, carton)
Paper

What to do:

1. Obtain a clean piece of paper. Crease it in one direction.

2. Hit the container against the palm of the hand until the chemicals are loosened.

3. Uncap the container and tilt it until it is almost horizontal over the paper.

4. Shake or roll the container back and forth and tap it gently as it is slowly tilted until the chemical begins to drop onto the creased paper. Stop shaking when the desired amount is obtained. Do not shake out more than is needed because it may not be returned to the container.

5. Recap the container and put it away.

10. Pouring a liquid chemical without splashing

Materials needed:

Liquid chemical in a container*
Glass rod
Receiving container

What to do:

Part A. Glass bottle with a glass stopper

1. Turn the right hand palm up and grasp the stopper between the middle and ring finger. (A left handed person should use the left hand in each place the right hand is designated.) Remove the stopper with a twisting motion. Do not lay the stopper down.

2. Grasp the bottle in the right hand with the stopper held between the fingers. Hold the bottle and stopper away from the body while pouring the chemicals.

3. Hold the glass rod against the lip of the bottle with the left hand if small quantities are to be poured. (Rest the lip of the bottle on the top edge of the clean receiving container if large quantities are desired.)

4. Tilt the bottle so that the lower end of the glass rod rests against the inside of the receiving container and pour the liquid slowly. Pour only the amount that is needed. Do not pour any excess back into the original bottle.

5. Set the bottle down and replace the stopper. Rinse the glass rod until clean.

* Have the pupils practice this procedure with water before using corrosive chemicals.

Part B. Glass bottle with screw cap

1. Unscrew the cap from the bottle. Turn the cap over so the open side is up and lay it on a table.

2. Grasp the bottle in the right hand.

3. Hold the glass rod against the lip of the bottle with the left hand if small quantities are to be poured. (Rest the lip of the bottle on the top of the clean receiving container if large quantities are desired.)

4. Tilt the bottle so that the lower end of the glass rod rests against the inside of the receiving container and pour the liquid slowly. Pour only the amount that is needed. Do not pour any excess back into the original bottle.

5. Set the bottle down and recap the bottle. Rinse the glass rod until clean.

Part C. Beaker, jar or drinking glass

1. Lay the glass rod across the top of the beaker.

2. Grasp the beaker with the right hand. Hold the glass rod in place with the right index finger.

3. Lift the beaker and tilt it slightly. Move the beaker to a place where the lower end of the glass rod rests against the inside of the receiving container. (Rest the lip of the beaker on the top of the clean receiving container if large quantities are desired.)

4. Tilt the beaker further. Pour the liquid slowly. Pour only the amount that is needed. Do not pour any excess back into the original beaker.

5. Set the beaker down. Rinse the glass rod until clean.

Part D. Transferring a liquid chemical drop by drop from a glass stoppered bottle

1. Loosen the stopper but do not remove it.

2. Grasp the bottle with the right hand. Hold the stopper with the left hand so that it does not fall out.

3. Tilt the bottle to a pouring position and gently push the stopper back and forth in the neck of the bottle to cause the drops to come out. Be sure the receiving container is directly below the lip of the bottle. Do not use a medicine dropper in the bottle of pure chemical solution or pour any excess chemical back into the bottle.

4. Set the bottle down and push the stopper firmly into the bottle.

11. Making student alcohol burners

Materials needed:

Glass bottle with cap (baby food jar or ink bottle)
Cap for narrow necked bottle
Alcohol
Wick (thick, loosely twisted string)
Hammer
Nail

What to do:

1. Obtain a short broad glass bottle with a screw top. Do not use a metal container.

2. Use a hammer and nail to punch a hole through the center of the cap, from bottom side up.

3. Obtain a dry length of loosely twisted, thick string (from engineer's floor mop).

4. Push the string through the hole, doubling it if necessary to make a snug fit. Pull the string through the cap until it extends 1/8" above the cap.

5. Have the teacher add alcohol until the bottle is about 1/4 full.

6. Light the wick and adjust the height of the wick for a small, blue flame.

7. Use the cap from a narrow necked bottle to cover the wick when extinguishing the flame.

12. Cutting window glass

Materials needed:

Glass cutter
Window glass
Ruler

What to do:

1. Place the glass on a firm, flat surface.
2. Put the ruler on the glass beside the place where the glass should be cut.
3. Make a scratch on the glass by pressing firmly on the glass cutter and drawing it once along the edge of the ruler.
4. Move the glass and place the scratch beyond the edge of the table so that it is possible to tap along the scratch on the underside of the glass.
5. Grasp the piece of glass which extends beyond the table. Increase the force of the tapping gradually until a crack moves along the scratch.

13. Heating test tubes

Materials needed:

Rectangular iron support
Test tube rack
Test tube, 6", Pyrex
Test tube holder
Burette clamp
Alcohol lamp or liquid petroleum burner

What to do:

1. Place the test tube in a burette clamp attached to an iron support when heating the test tube very hot or for a long period of time. Tilt the test tube at a slight angle from the vertical.

2. Use a test tube holder only when heating a test tube for a short period of time. Tilt the test tube at a slight angle from the vertical.

3. Place the test tube in a test tube rack to cool. Do not put extremely hot test tubes in a test tube rack.

(CAUTION: When heating a test tube, never "point" the open end at someone.)

14. Heating Pyrex flasks

Materials needed:

Flask, Florence or Erlenmeyer, Pyrex
Burette clamp
Ring clamp
Rectangular iron support
Liquid petroleum burner
Wire gauze

What to do:

1. Attach the ring clamp to the rectangular iron support. Adjust its height to approximately 2" above the top of the liquid petroleum burner.

2. Place the wire gauze on the ring clamp.

3. Fasten the neck of the flask in a burette clamp. Lower the burette clamp onto the support until the flask rests on the wire gauze. Fasten the burette clamp firmly onto the support.

4. Place the liquid petroleum burner under the flask. (Do not heat glass jars or other "ordinary" glass containers.)

15. Making a glowing wood splint for oxygen test

Materials needed:

Match
Wood splint

What to do:

1. Light the end of the wood splint. Allow it to burn for 30 seconds.

2. Blow out the flame to obtain a glowing end.

16. Testing for starch in materials

Materials needed:

Tincture of iodine (poisonous)
Water
Medicine dropper
2 Test tubes, 6", Pyrex
Teaspoon
Test tube rack
Glass rod

What to do:

1. Place two test tubes in the test tube rack.

2. Pour water to the depth of 1" into each test tube.

3. Add $\frac{1}{2}$ teaspoonful of the material to be tested to the first test tube and stir with a glass rod.

4. Add a drop of weak tincture of iodine to each test tube.

5. Observe each test tube carefully. Compare the color of the liquid in the test tubes.

6. Assume that starch turns deep blue or purple when iodine is added.

17. Testing for carbon dioxide

Materials needed:

Limewater
Glass jar, (baby food)
Sample of carbon dioxide in a closed container
Rubber tubing, about 3' long

What to do:

Part A. Testing a gas in a container

1. Remove the cover of the container and pour ¼" of clear limewater slowly into the sample in the container. Cover the container immediately and shake the solution.

2. Observe the appearance of the limewater. Explain what evidence there is that a chemical action has occurred.

Part B. Testing the exhaled gas from a pupil's lungs

1. Pour ½" of clear limewater into the glass jar.

2. Place one end of the rubber tubing in the glass jar under the surface of the limewater. Place the other end of the rubber tubing into a child's mouth and have him exhale through the tube. Allow the exhaled air to bubble through the limewater for approximately two minutes.

3. Observe the limewater. Explain what evidence there is that a chemical reaction has occurred.

18. Preparing a filter and funnel stand

Materials needed:

Filter paper*
Glass filter funnel
Coat hanger, wire
Pliers
Ruler
Glass jar, (baby food)

What to do:

1. Cut the hook and twist off a wire coat hanger with the pliers. Straighten out the wire.

2. Shape one end of the wire into a small ring about 2 inches in diameter.

3. Bend the wire so that the 2" ring makes a 90° angle with the remainder of the wire ring.

4. Make a large ring in the wire including all the rest of the wire six inches below the small ring.

5. Bend the larger ring at right angles to the 6" length of wire so that the smaller ring is directly above the larger ring.

6. Adjust the 2" ring smaller or larger as necessary to hold the filter funnel. Rest the funnel on the top of the 2" ring in the wire. Place the baby food jar beneath the stem of the funnel.

* For many filtering experiences a two-inch square of paper hand towel may be used in place of filter paper. Fold the paper twice to form equal quarters. With scissors round the sides which do not have folds to form an arc and then continue as above in step #8.

7. Fold one sheet of the round filter paper in half. Fold the paper again to form a quarter circle.

8. Place the folded filter paper in the funnel with the point down. Spread the filter paper apart forming a cone shape with one thickness of paper on one side and three thicknesses on the other.

9. Moisten the filter paper with a little water and press it firmly against the sides of the funnel all the way around.

10. Pour the material to be filtered on the filter paper and allow the liquid which passes through the paper to drain into the glass jar.

For discussion purposes only

IS THERE A FIRE EXTINGUISHER IN THE CLASSROOM?

IS THERE AN EMERGENCY CARE CHART

(PREPARED BY THE DEPARTMENT OF HEALTH, PHYSICAL EDUCATION AND RECREATION, MINNEAPOLIS PUBLIC SCHOOLS)

IN THE CLASSROOM FOR READY REFERENCE?

IS THERE A FIRST AID KIT IN THE CLASSROOM?

VI. LEARNING ACTIVITIES

No. 1: Grouping substances according to their state (solid, liquid, or gas) at room temperature

Materials needed:

Pencil
Paper

What to do:

1. Make a chart with three main headings or columns: Solids, Liquids, and Gases.

2. Write the names of many different common substances in the appropriate column which describes the substance at room temperature.

3. Continue the listing until there are some common substances listed in each column.

4. Draw a conclusion about the state of any substance at room temperature.

No. 2: Discovering that a physical change in salt does not require a chemical change to occur

Materials needed:

1 tsp. - Salt
1 cup - Water
2 - Clean teaspoons
1 - Clean drinking glass
Watch glass

What to do:

1. Wash your hands with soap and be sure the spoons and drinking glass to be used are clean and dry.

2. Pour a few grains of salt into the clean teaspoon.

3. Taste one grain of salt.

4. Place the other spoon on top of the first spoon so that the bowl of the spoon containing the salt is beneath the bowl of the other spoon and the two handles are pointing in opposite directions.

5. Put the bottom spoon on a table and press down with the top spoon to grind the salt to a powder.

6. Taste a small portion of the powder and determine whether it is still salt.

7. Place one inch of water in the glass.

8. Taste the water to find out if it is salty. Add 1/4 teaspoon of salt to the water. Stir the water and taste it again. Observe whether it tastes salty.

9. Pour some of the salty water into a watch glass and allow the water to evaporate.

10. Observe what is left on the watch glass. Answer the question, "Has the salt been changed chemically?"

11. Draw a conclusion based on the results.

No. 3: Observing some physical characteristics of a salt solution

Materials needed:

Watch glass
Salt
Water
Jar, peanut butter, or large water tumbler
Paper
Tablespoon
Pencil
Filter paper
Funnel
Funnel stand
Thermometer, Celsius (or centigrade) or Fahrenheit
Hand lens

What to do:

1. Fill the jar about one half full of water at room temperature.

2. Use the thermometer to measure the temperature of the water. Record the temperature.

3. Stir the water vigorously. Measure the temperature of the water to determine whether stirring heats the water. Read carefully and record any change in temperature.

4. Add about two tablespoonfuls of salt. Stir the mixture vigorously.

5. Read carefully and record the temperature of the resulting salt solution as soon as most of the salt has dissolved.

6. Prepare a filter paper in a funnel which is supported in a funnel stand.

7. Pour some of the solution onto (or into) the filter paper. Collect a dozen drops of the clear liquid on the clean watch glass.

8. Place the watch glass and liquid in the sun or over a warm radiator and allow the water to evaporate.

9. Observe the material remaining on the watch glass carefully using a hand lens.

10. Summarize and record the observations. Draw a conclusion based on the results.

No. 4: Separating a mixture using physical properties

Materials needed:

Salt
Sand
Iron filings
Teaspoon
Magnet, permanent
Funnel stand
Filter paper
Water
Glass filter
Funnel
Paper, creased
Magnifying glass
Watch glass
Jar, (baby food)

What to do:

1. Examine each of the materials with the magnifying glass.
2. Mix one teaspoon each of salt, sand, and iron filings together on a piece of clean paper.
3. Observe the appearance of the mixture carefully with the magnifying glass.
4. Stir the mixture with the magnet. Observe what happens.
5. Prepare a filter in the glass funnel.
6. Pour the remainder of the mixture into the filter paper.
7. Wash the mixture several times with a small quantity of warm water.
8. Remove the filter paper from the funnel and spread it cut to dry. Observe and record.
9. Pour some of the liquid in the baby food jar onto a watch glass. Allow the liquid to evaporate. Observe and record.
10. Observe the material on the magnet collected in step 3 on the filter paper collected from step 7 and on the watch glass collected in step 8 with a magnifying glass.
11. Summarize the observations.
12. Explain whether chemical or physical properties have been used to separate the mixture.

No. 5: Growing crystals from substances (physical change)

Materials needed:

Alum, (potassium aluminum sulfate)
Copper sulfate
Epsom salts, (magnesium sulfate)
Water
Match sticks, 4
Watch glasses, 2
Test tubes, about ½" x 6", Pyrex, 2
Hand lens
Teaspoon

What to do:

1. Place 1/8 teaspoonful of the copper sulfate in a test tube.
2. Add only as much water as necessary to completely dissolve the copper sulfate in the test tube.
3. Pour the solution into a watch glass.
4. Place the watch glass on a shelf where it won't be disturbed. Allow the water to evaporate.
5. Observe the material left on the watch glass with a hand lens.
6. Repeat steps 1 - 5 using Epsom salts or alum rather than copper sulfate.
7. Vary the procedure by placing the watch glass on a shelf and placing a bowl over it. Place four match sticks under the edge of the bowl to allow some ventilation.
8. Observe the crystals that form with a hand lens. Compare these crystals to those formed in the uncovered watch glass.
9. Explain the observations. Draw conclusions based on the results.

No. 6: Observing a physical and chemical change in paper

Materials needed:

Paper
Wire gauze with asbestos center
Match

What to do:

1. Examine a piece of paper.

2. Tear half of the paper into small pieces.

3. Examine the small pieces and the larger remaining piece of paper.

4. Explain how these things are different. Answer the question, "Is each small piece paper?"

5. Place the small pieces of paper on the wire gauze.

6. Light a match and set fire to the small pieces of paper on the asbestos.

7. Examine the material left after the small pieces of paper finish burning. Answer the question, "Is what remains still paper?"

8. Explain the different results of tearing vs. burning paper.

No. 7: Illustrating the differences between a chemical and physical change in wood

Materials needed:

Wood
Saw or sandpaper
Wire gauze
Match

What to do:

1. Saw or sand a piece of wood.
2. Examine the wood dust and the larger remaining pieces of wood.
3. Explain how these are different. Answer the question, "Are they still wood?"
4. Place some wood dust on the wire gauze.
5. Light a match and set fire to the sawdust.
6. Examine the material left after the wood dust finishes burning. Answer the question, "Is it still wood?"
7. Explain the different results of sawing vs. burning wood.

No. 8: Observing a physical and a chemical change in steel wool

Materials needed:

Water
Pencil
Steel wool
Scissors
Glass jar
2 test tubes, 6", Pyrex
Rectangular iron support
Burette clamp
Magnifying glass

What to do:

1. Loosely pack a ball of steel wool in the bottom of a test tube (or dampen a test tube and put iron filings into it). Use a pencil to push the steel wool down.

2. Moisten the steel wool with water.

3. Fill the glass jar one half full of water.

4. Turn the test tube over and place its mouth under the surface of the water in a glass jar. Clamp the test tube firmly with a burette clamp attached to a rectangular iron support.

5. Adjust the height of the test tube until the level of the water inside the test tube is the same as the water level outside the test tube.

6. Do not disturb the glass jar for a day or two.

7. Note the height of the water level in the test tube after a couple of days. Observe the difference in appearance of the steel wool.

8. Cut or pull a strand of steel wool into two pieces. Compare the two pieces. Explain how cutting changes the steel wool.

9. Examine a long strand of steel wool under a magnifying glass. Cut a long piece of steel wool into short pieces with a scissors. Examine a short piece with a magnifying glass.

10. Compare the two pieces and explain how they are different.

11. Remove the rusted steel wool from the test tube.

12. Examine a strand of new, not rusted steel wool and a strand of rusted steel wool with a magnifying glass.

13. Try to bend a piece of new (not rusted) steel wool and a piece of rusted steel wool. Compare them.

14. Explain why the steel wool from the test tube is different and why the water level changed in the test tube.

15. Explain how to tell the difference between a physical and a chemical change.

No. 9: Using taste to obtain evidence of a chemical change

Materials needed:

White bread, 1 piece

What to do:

1. Put a piece of white bread in your mouth. Hold your nose and determine whether the bread tastes sweet.

2. Chew the bread thoroughly. Keep it in your mouth for two minutes.

3. Hold your nose. Determine if the bread has any different taste.

4. Explain how the changed taste provides evidence that a chemical change has taken place.

No. 10: Observing mixtures of materials to determine whether a physical and/or a chemical reaction occurs

Materials needed:

Vinegar
Salt
Water
Teaspoon
Drinking glass
Baking soda
Flour

What to do:

1. Fill the drinking glass 1/2 full of water.
2. Add a teaspoonful of vinegar and a teaspoonful of salt to the water. Stir.
3. Taste the solution. Note whether the sour (vinegar) and salty tastes still persist. Do not taste the solution unless the equipment is thoroughly clean before the activity is begun.
4. Explain whether the observations indicate that a chemical reaction has occurred.
5. Repeat the activity using vinegar and baking soda.
6. Repeat using flour and salt.
7. Repeat using salt and baking soda.
8. Summarize the observations. (Note: If other pairs of substances are used, be sure they are not poisonous. Many household substances are poisonous.) Draw conclusions based on the observations.

No. 11: Observing a heat change accompanying a physical change in a chemical substance

Materials needed:

Photographic hypo (Sodium thiosulphate)
Test tube, 6", Pyrex
Rectangular iron support
Alcohol lamp
Graph paper
Burette clamp
Thermometer, centigrade or Fahrenheit
Pencil
Paper

What to do:

1. Support the test tube vertically in the burette clamp which is attached to the rectangular iron support.

2. Fill the test tube one half full with photographic hypo.

3. Light the alcohol lamp.

4. Heat the test tube very slowly until all of the photographic hypo melts.

5. Extinguish the alcohol lamp.

6. Place the thermometer in the test tube. Read and record the temperature.

7. Read and record the temperature at 30 second intervals.

8. Graph the temperature against the time. Note any unexpected change in the general cooling process.

9. Explain the observations.

No. 12: Studying a physical change brought about by heat

Materials needed:

2 Test tubes, 6" long, Pyrex
Burette clamp
Rectangular iron support
Alcohol lamp
Glass jar, (baby food)
Water

What to do:

1. Suspend a clean test tube containing about 1" of water from burette clamp attached to the support.

2. Light the alcohol lamp and heat the water slowly.

3. Fill the glass jar 3/4 full with cold water. Hold the bottom of it near the mouth of the test tube when the water in the test tube begins to boil.

4. Observe the surface of the cold glass jar carefully.

5. Extinguish the alcohol lamp.

6. Explain whether a physical or a chemical change has occurred.

No. 13: Observing the temperature of water during a change in state

Materials needed:

Crushed ice
Thermometer, Celsius or Fahrenheit
Glass jar, (baby food)
Pencil
Paper
Graph paper

What to do:

(Note: Start this activity at the beginning of the school day.)

1. Place the thermometer in the glass jar.
2. Fill the jar one half full with ice.
3. Read and record the temperature and the time.
4. Make a record of the time, temperature and an estimate of the amount of ice left in the jar every two minutes until the water reaches the temperature of the room.
5. Graph the time against the temperature.
6. Study the graph. Attempt to draw conclusions concerning the change in water temperature as heat from the air in the school room is added.

No. 14: Observing physical changes in water

Materials needed:

Ice
Flask, Florence or Erlenmeyer, 250 ml, Pyrex
One-hole rubber stopper
Milk carton
Glass tubing, 10", 6 mm inside diameter
Liquid petroleum burner
Ring clamp
Rectangular iron support
Burette clamp
Glass jar
Wire gauze

What to do:

1. Bend the 10" glass tubing into an acute angle about 2" from one end. Fire polish both ends.
2. Insert the short end of the tubing through the hole in the stopper from upper side to lower side.
3. Hang the flask vertically from a burette clamp attached to a rectangular iron support.
4. Support it from below with a wire gauze resting on a ring clamp attached to the support.
5. Fill the flask 1/2 full of water.
6. Insert the rubber stopper with bent glass tube into the flask with a slight twisting motion.
7. Place a test tube in a jar filled with crushed ice.
8. Adjust the flask assembly or the test tube and jar until the long end of the glass tubing is inside and near the bottom of the cooled test tube.
9. Light the liquid petroleum burner.
10. Heat the bottom of the flask slowly with the burner.
11. Notice the water appearing in the bottom of the test tube after a period of time.

12. Explain how the water got into the test tube.
13. Pour about 1" of the water from the test tube into a clean milk carton.
14. Place the milk carton in the freezing compartment in the refrigerator (or outside the classroom on the window ledge on a very cold winter day).
15. Observe the water in the milk carton the next day. Explain how the water has changed.
16. Allow the ice to melt. Explain whether the water has been changed to a new substance by a chemical reaction.
17. Draw conclusions based on the observations.

No. 15: Observing a heat change accompanying a chemical change

Materials needed:

Tablespoon
Plaster of Paris
Glass jar
Thermometer, centigrade or Fahrenheit
Water
Pencil
Paper

What to do:

1. Pour 1" of water into the glass jar.
2. Place a thermometer in the jar. Read and record the temperature. Remove the thermometer.
3. Place 5 tablespoonfuls of plaster of Paris in the glass jar.
4. Mix thoroughly with the spoon making sure all the powder is wet.
5. Place the thermometer in the jar again. Read and record the temperature. Remove the thermometer before the plaster hardens.
6. Compare the temperatures.
7. Suggest a reason for the observed differences in temperature.

No. 16: Observing heat produced by a chemical reaction

Materials needed:

Thermos bottle, with wide mouth
Water, at room temperature
Cement, portland
Thermometer, centigrade or Fahrenheit
Cotton batting
Stirring rod
Paper nut cup, small
Pencil
Paper

What to do:

(Note: Start this at the beginning of a school day.)

1. Make a cotton plug for the opening in the thermos bottle.
2. Add cement to the nut cup until it is 1/2 full.
3. Add enough water to the cement to wet it thoroughly.
4. Place the nut cup in the bottom of the thermos bottle.
5. Place the thermometer in the thermos bottle but not in the nut cup.
6. Close the opening with the cotton plug.
7. Read and record the temperature and the time.
8. Record the temperature every 30 minutes until the cement hardens or until school is dismissed.
9. Summarize the results. Draw conclusions based on the results.

No. 17: Discovering there is energy in nuts

Materials needed:

Nuts, such as walnut, peanut, almond
Needle, long
Cork

What to do:

1. Push the eye of the needle into the center of the top of the cork. Adjust the needle to an upright position.

2. Mount one of the nuts on the point of the needle.

3. Light the nut with a match. Observe how well the nut flames.

4. Repeat steps 2 and 3 using different kinds of nuts.

5. Explain how the observations indicate that there is chemical energy in nuts.

No. 18: Obtaining some evidence for the oxidation of foods by the human body

Materials needed:

Alcohol lamp
Bread, thoroughly dry
Test tube holder
Cloth towel
Sipper straw
Glass jars, wide mouth, 2
Glass jar, filled with cold water
Limewater

What to do:

1. Dry the outside of the jar of cold water. Breathe on the jar and look for evidence of water vapor.
2. Pour lime water into one of the wide mouth glass jars to a depth of about 1/2".
3. Grasp a piece of thoroughly dry bread with the test tube holder.
4. Light the alcohol lamp and heat the bread until it catches fire.
5. Dry the outside of the jar of cold water. Hold the jar of cold water above the flaming bread to test for the presence of water vapor forming as the bread burns.
6. Hold the burning bread in the jar containing limewater. Do not wet the bread with the limewater. Note whether there is evidence of the presence of carbon dioxide.
7. Compare the results of burning bread with the results of burning a fuel.
8. Place about 1/2" of limewater in the second wide mouth glass jar.
9. Blow the breath gently from the lungs through the straw into the liquid to test for carbon dioxide in the breath.
10. Record the results and draw conclusions.

No. 19: Decomposing baking soda with heat

Materials needed:

2 Test tubes, 6", Pyrex
Burette clamp
Rectangular iron support
Wood splint
Alcohol lamp
Baking soda

What to do:

1. Place a test tube in a vertical position in the burette clamp which is attached to the rectangular iron support.
2. Add 1" of baking soda (sodium bicarbonate) to the test tube.
3. Light the alcohol lamp.
4. Lower the burette clamp until the bottom of the test tube is just above the flame.
5. Observe the moisture collecting on the sides of the test tube. Explain where the water has come from.
6. Light a wood splint.
7. Hold the burning splint in the mouth of the test tube for a short period of time to test for carbon dioxide. Observe what happens. Remove the splint from the test tube.
8. Check the significance of the observation by relighting the wood splint and holding the splint in the mouth of an empty test tube for a short period of time. Observe what happens. Remove the splint from the test tube.
9. Repeat steps 7 and 8 at least three times to verify the observations.
10. Make sure the wood splint is extinguished. Extinguish the alcohol lamp.
11. Explain what has happened. Consult reference materials if necessary. Explain and evaluate the evidence that the liquid formed is water. Explain and evaluate the evidence that the gas formed is carbon dioxide.
12. Explain how the baking soda has been changed.

No. 20: Decomposing sugar with heat

Materials needed:

Cane or beet sugar
Test tube, 6", Pyrex
Rectangular iron support
Burette clamp
Alcohol lamp
Jar of cold water

What to do:

1. Place 1" of sugar in a test tube.

2. Suspend the test tube at a slight angle from the horizontal in the burette clamp attached to the rectangular iron support.

3. Light the alcohol lamp.

4. Raise the clamp to a height which places the bottom side of the test tube about 2" above the visible flame.

5. Heat the sugar <u>very slowly</u>.

6. Observe and record the change in appearance of the sugar as it is heated.

7. Explain whether a chemical or a physical change is taking place.

8. Move the test tube closer to the flame, heating the sugar more strongly.

9. Hold the side of a jar of cold water near the mouth of the test tube. Be sure the jar of cold water is dry on the outside before using.

10. Observe the surface of the outside of the jar and the appearance of the contents of the test tube. Identify the substance which has condensed on the cold jar and the material left in the test tube. (Note: This experience could be obtained with less equipment by using a spoon to hold the sugar; however, it probably would be more difficult to observe the changes.)

11. Draw conclusions based on the results.

No. 21: Changing a substance using heat energy

Materials needed:

Copper sulfate
Epsom salts, magnesium sulfate
Test tubes about $\frac{1}{2}$" x 6", Pyrex, 2
Test tube rack
Alcohol lamp
Water
Medicine dropper

What to do:

1. Add copper sulfate to a depth of $\frac{1}{4}$" in one test tube. Observe any color change of the solid.

2. Light the alcohol lamp.

3. Grasp the test tube with a test tube holder and holding the test tube at an angle to the vertical, heat the solid slowly. Shake the test tube occasionally to stir the solid.

4. Observe any color change of the solid.

5. Extinguish the alcohol lamp. Continue to hold the test tube until it is cool enough to set in the rack. Set the test tube in the test tube rack and allow it to cool to room temperature.

6. Wet the solid with one drop of water. Observe the results.

7. Repeat steps 1 - 5 using Epsom salts. Remove the test tube from the flame after one minute. Listen carefully to hear a sizzling sound as water comes from the Epsom salts. Be careful to avoid leaning over the flame or touching the hot test tube against the skin. Do not place the ear too close to the opening of the test tube since the escaping steam may cause a burn.

8. Explain the observations. Consult references if necessary.

No. 22: Discovering that heating a metal does not always produce a chemical change

Materials needed:

Zinc metal strip
Burette clamp
Rectangular iron support
Test tube, 6", Pyrex
Alcohol lamp
Pencil
Paper

What to do:

1. Place a small strip of zinc in a clean dry test tube.

2. Support the test tube with a burette clamp attached to a rectangular iron support.

3. Light the alcohol lamp.

4. Heat the test tube and observe what happens to the zinc.

5. Allow the test tube to cool.

6. Extinguish the alcohol lamp.

7. Observe the appearance of the zinc. Explain whether a chemical reaction has occurred. Draw conclusions based on the observed results.

8. Write the symbol for zinc.

No. 23: Breaking down a complex organic substance into other substances

Materials needed:

Rectangular iron support
Burette clamp
Test tube, 6", Pyrex
Wood shavings or powdered coal
Alcohol lamp
Cotton batting
Rubber stopper, 1 hole, size #1
Glass tubing drawn into tip with small opening, 2"
Pencil
Paper

What to do:

1. Place the burette clamp on the rectangular iron support.

2. Place the fine wood shavings or powdered coal in the test tube. Do not fill over 1/2 full.

3. Suspend the test tube vertically in the clamp and tighten the clamp firmly around the tube.

4. Place a loose cotton plug in the mouth of the test tube.

5. Insert the blunter edge of the glass tubing into the stopper. (Use of a cork is preferred but it may be difficult to make a hole through the cork unless special equipment is available.)

6. Twist the stopper into the test tube tightly.

7. Turn the test tube in the clamp so that the mouth is tipped slightly below the horizontal.

8. Light the alcohol lamp.

9. Lower the test tube so that it can be heated with the alcohol lamp. Apply the heat at the end of the test tube away from the stopper. Do not heat the cotton.

10. Observe the tube as it is heated. Explain where the water comes from. Explain why the cotton turns brown even though it is not heated.

11. Attempt to light the gas escaping from the tip of the glass tubing with a match. (If the wood or coal is not heated strongly and if you do not test it at the opportune moment, the gas might not catch fire.)

12. Explain why the gas burns. Consult references to find the name of this gas.

13. Continue to heat the test tube until the reaction has stopped.

14. Allow the test tube to cool to room temperature. Extinguish the alcohol lamp.

15. Remove the stopper and cotton plug. Pour the material remaining in the bottom of the test tube onto a clean piece of paper. Loosen it with a pencil if necessary. Observe the brown material coating the side of the test tube.

16. Explain what this material on the side of the test tube is. Use references to find the name of this solid.

17. Prepare an oral report on the economic importance of the brown material (coal tar) which coats the cotton when coal is heated. Consult references for information.

13. Continue to heat the test tube until the reaction has stopped.

14. Allow the test tube to cool to room temperature. Extinguish the alcohol lamp.

15. Remove the stopper and cotton plug. Pour the material remaining in the bottom of the test tube onto a clean piece of paper. Loosen it with a pencil if necessary. Observe the brown material coating the side of the test tube.

16. Explain what this material on the side of the test tube is. Use references to find the name of this solid.

17. Prepare an oral report on the economic importance of the brown material (coal tar) which coats the cotton when coal is heated. Consult references for information.

No. 24: Studying a chemical change brought about by heat
(Teacher Demonstration)

Materials needed:

2 Test tubes, 6" long, Pyrex
Rectangular iron support
Burette clamp
Alcohol lamp
Wood splint
Potassium chlorate
Manganese dioxide
Teaspoon
Paper, 2 pieces
Pencil

What to do:

1. Place a level teaspoon of potassium chlorate on a piece of clean paper which has been creased for easy pouring.
2. Add 1/4 teaspoon of manganese dioxide. Mix thoroughly. Explain whether a physical or chemical change has occurred.
3. Pour the mixture into a test tube.
4. Support the test tube vertically in a burette clamp attached to a rectangular iron support.
5. Light the alcohol lamp.
6. Light a wood splint. Blow out the flame to obtain a glowing end.
7. Heat the test tube. Test for evidence of the formation of oxygen by putting the glowing wood splint inside the opening of the test tube.
8. Allow the test tube to cool. Extinguish the alcohol lamp.
9. Explain whether a physical or chemical change has occurred. Write the symbol for oxygen.

No. 25: Testing the flammability of substances

Materials needed:

Chalk
Bread
Leather shoe lace
Teaspoon
Plastic ruler
Paper hand towel
Soap
Wood splint
Lock of hair
Glass jar
Water
Test tube holder or tongs
Alcohol lamp

What to do:

1. Fill the glass jar with water.

2. Light the alcohol lamp.

3. Grasp one of the materials at a time (see list of materials needed) with the test tube holder or tongs.

4. Hold each substance in the flame and observe whether it begins to burn. Time how long the material is heated before it begins to burn. Observe that some materials do not begin to burn.

5. Extinguish the burning materials in the jar of water.

6. Observe each material which burns and note any changes in its appearance.

7. Cool the hot, unburned materials by placing in cool water before they are laid down.

8. Extinguish the alcohol lamp.

9. Explain why the test does not give definite proof that the materials which did not burn are not able to burn.

10. Conclude whether different substances burn equally well.

No. 26: Comparing the flammability of different substances which have a common trait (Teacher Demonstration)

Materials needed:

Wool cloth, 4" x 4"
Nylon cloth, 4" x 4"
Cotton cloth, 4" x 4"
Test tube holder or tongs
Alcohol lamp
Glass jar
Water
Pencil
Wax paper, 4" x 4"
Onion skin paper, 4" x 4"
Cellophane, 4" x 4"
Piece of sheet plastic, 4" x 4"
Aluminum foil, 4" x 4"
Asbestos sheet, 4" x 4"
Chalk
Glass rod

What to do:

1. Fill the glass jar with water.
2. Light the alcohol lamp.
3. Grasp one of the materials at a time (see list of materials needed) with the test tube holder or tongs.
4. Hold each substance in the flame and observe whether it begins to burn. Time by counting how long the material is heated before it begins to burn. Observe that some materials do not begin to burn.
5. Extinguish the burning materials in the jar of water.
6. Observe each material which burns and note any changes in its appearance.
7. Cool the hot, unburned materials by placing in cool water before they are laid down.
8. Extinguish the alcohol lamp.
9. Explain why the test does not give definite proof that the materials which did not burn are not able to burn.
10. Conclude whether materials having a common trait are equally flammable.

No. 27: Determining the effect of chemicals on plant growth

Materials needed:

4 Healthy plants, about the same size, such as geranium or coleus
Liquid fertilizer
Vinegar or Hilex
Distilled water
Pencil
Paper

What to do:

1. Number the plants in consecutive order. Prepare a record sheet for each plant. Record the treatment of each plant.

2. Measure the same total amount of liquid (water, fertilizer and/or vinegar) for each plant at every watering. Guard against over or under watering.

3. Water plant number 1 with distilled water twice a week.

4. Water plant number 2 twice a week with distilled water and with liquid fertilizer once a month.

5. Water plant number 3 with liquid fertilizer twice a week.

6. Water plant number 4 with vinegar twice a week.

7. Keep the plants in the sunlight on a warm window ledge. Observe the plants twice a week and record all observations of their apparent health and growth.

8. Continue the observations until a difference is noted among all four plants.

9. Draw some conclusions in regard to the different effects chemicals have on plants.

No. 28: Becoming familiar with the commonly used test for evidence that some materials were once alive (organic)

Materials needed:

Samples of many different materials, such as: sugar, salt, wood shavings, soap powder, sand, bread
Alcohol lamp
Glass jar
Water
Metal teaspoon
Oven mitt

What to do:

1. Fill the glass jar half full of water.

2. Light the alcohol lamp.

3. Place a small quantity of one of the samples in the teaspoon. Use an oven mitt to grasp a spoon handle.

4. Hold the teaspoon with the sample in it over the flame until it is thoroughly heated. Observe and record what happens. (Dip the spoon with the heated material into the jar of water if the flame seems to be getting out of control.)

5. Remove the teaspoon from the flame and hold the spoon until it has cooled. Examine the spoon to observe any evidence of charring.

6. Repeat the experience with each of the other samples.

7. Extinguish the alcohol lamp.

8. Summarize the observations. Indicate which observations are common to materials which were once alive. Examine reference materials to find out about these chemical reactions.

9. Explain how this test depends on the assumption that all things that were once alive contain carbon.

No. 29: Identifying the substances formed when sugar burns

Materials needed:

Alcohol lamp
Glass jar
Sugar cube
Jar lid
Ashes, wood, paper, or cigarette
Limewater
Test tube holder

What to do:

1. Light the alcohol lamp.
2. Rub ashes into the sugar cube.
3. Grasp the sugar cube with a test tube holder. Ignite the sugar cube by holding it over the flame.
4. Place the burning sugar cube on a jar lid. Invert a cold, clean, dry jar over it.
5. Observe and record whether moisture forms on the inside of the jar. Note whether anything is deposited on the sides or bottom of the jar.
6. Extinguish the alcohol lamp.
7. Pick up the jar, holding the lid tightly over the mouth of the jar. Turn the jar over.
8. Remove the lid and pour 1/4" of limewater into the jar. Replace the lid.
9. Shake the jar. Observe and record what has happened.
10. Summarize the results of all observations.

No. 30: Dissolving limestone with weak acids

Materials needed:

Limestone, 4 small pieces
Vinegar
Lemon juice
Water
Acid, hydrochloric (10% solution)

What to do:

1. Place two drops of vinegar on a piece of limestone.
2. Place two drops of lemon juice on a second piece of limestone.
3. Place two drops of water on a third piece of limestone.
4. Place two drops of hydrochloric acid on a fourth piece of limestone.
5. Observe the rocks closely to find on which pieces of limestone there is evidence of any chemical reaction.
6. Compare the observations. Summarize the results. (Any weak acid dissolves limestone slowly. Even carbon dioxide dissolved in water is a weak acid which can dissolve limestone. Carbon dioxide bubbles which form should be visible after 2 or 3 minutes.)

No. 31: Making carbon dioxide from rock

Materials needed:

Limestone or marble chips
Vinegar
Wood splint
Rectangular iron support
Burette clamp
Cloth towel
Wire gauze
Alcohol lamp
Water
Limewater
Erlenmeyer flask, 250 ml, Pyrex
Thistle tube
2 Hole rubber stopper, (#6 or 6½)
Rubber tubing, about 3' long
Glycerine
Glass tubing, 4" long, 6 mm internal diameter
Ring clamp

What to do:

1. Place a ½" layer of limestone or marble chips in the flask.

2. Add water to the depth of 1".

3. Push the tubing through one hole of the two hole rubber stopper.

4. Lubricate the outside of the tube end of the thistle tube with glycerine. Wrap a cloth around the tubing and push it through the other hole of the rubber stopper far enough so that the lower end of the tube is beneath the surface of the water when the stopper is fitted to the flask.

5. Attach the rubber tubing to the short piece of glass tubing. Place the other end of the rubber tubing in a beaker.

6. Place the flask on the wire gauze resting on the ring clamp on the rectangular iron support. Secure the flask in place with a burette clamp at the neck.

7. Pour vinegar into the thistle tube.

8. Light the alcohol lamp and heat the flask gently.

9. Test for an indication of the presence of carbon dioxide in the beaker with a burning wood splint. Observe whether the flame is extinguished.

10. Remove the end of the rubber tubing from the beaker. Extinguish the alcohol lamp.

11. Test for further evidence of the presence of carbon dioxide by pouring some clear limewater into the beaker.

12. Observe what happens. Draw conclusions based on the results.

No. 32: Producing carbon dioxide gas by a chemical reaction with ingredients found in a kitchen

Materials needed:

Vinegar
Baking soda
Wood splint
Tablespoon
Water
Beaker, 400 ml, Pyrex

What to do:

1. Add 2" of water to the beaker.

2. Add 2 tablespoonfuls of baking soda (sodium bicarbonate) to the water. Stir.

3. Light a match and ignite a wood splint.

4. Pour some vinegar (acotic acid solution) into the baking soda solution.

5. Observe what happens.

6. Bring the flaming wood splint over the top of the beaker, taking care that the splint does not get wet. Observe what happens.

7. Explain how the observation indicates the presence of carbon dioxide.

8. Explain how this experiment provides evidence that oxygen is needed for combustion. Consult a reference if necessary.

9. Write the formula for carbon dioxide.

10. Add vinegar a little at a time until no further reaction occurs.

11. Taste the solution to determine whether the taste of vinegar or baking soda remains. (Do not taste the solution unless the beaker and spoon were sterilized before the experiment was started. Generally it is impossible to get exact proportions so the solution should taste. Never taste an unknown substance since many chemicals are poisonous.)

12. Draw conclusions based on the results.

No. 33: Discovering the chemistry of a leavening agent

Materials needed:

Baking powder
Baking soda
Cream of tartar
Wood splint
Glass jars, 3
Water
Teaspoon
Litmus paper, neutral
Tincture of iodine

What to do:

1. Place one teaspoon of baking soda and one teaspoon of cream of tartar in a glass jar. Mix thoroughly.

2. Test for the presence of carbon dioxide with a burning wood splint.

3. Add water to the jar to a depth of 1". Observe whether bubbles appear in the liquid. Test for carbon dioxide again.

4. Dip a piece of litmus paper into the solution. Observe whether the solution is acid or alkaline.

5. Place one teaspoonful of baking powder in the second jar.

6. Test for the presence of carbon dioxide.

7. Add water and observe whether bubbles appear. Test for the presence of carbon dioxide.

8. Dip a piece of litmus paper into the solution. Observe whether the solution is acid or alkaline.

9. Add a drop of tincture of iodine to test the liquid for starch. Consult a reference to find why starch is put into baking powder.

10. Place $\frac{1}{4}$ teaspoonful of cream of tartar in a glass jar. Add water to the depth of 1".

11. Dip the end of a piece of litmus paper into the solution. Observe whether the solution is acid or alkaline.

12. Compare the reaction of wet baking powder to the reaction of wet baking soda and cream of tartar.

13. Explain what chemical reaction is used in these two methods of producing carbon dioxide. (Both of these methods are used in leavening of cake.)

No. 34: Studying the properties of sulfur

Materials needed:

Sulfur, flowers of, or roll
Metal spoon, old
Glass jar
Water
Alcohol lamp
Oven mitt

What to do:

1. Fill the jar with cold water.

2. Light the alcohol lamp.

3. Place a small piece of roll sulfur in the spoon or add powdered sulfur to the spoon until 1/2 full. Use an oven mitt to grasp the spoon handle.

4. Heat the bottom of the spoon very slowly, holding the spoon high over the flame. Do not heat fast enough for "smoke" or visible vapors to appear. Do not heat it so rapidly that the sulfur catches fire.

5. Note that as the sulfur begins to melt it is very "runny".

6. Pour two or three drops of the melted sulfur into cold water. Save the sulfur globules for later use.

7. Continue heating the sulfur in the spoon.

8. Note that as the sulfur becomes hotter it becomes less easy to pour (very viscous).

9. Pour a drop of the more viscous sulfur into cold water. (This may be difficult to do.)

10. Continue heating and notice the white sulfur fumes which form. (Flowers of sulfur are made by vaporizing sulfur and collecting the finely divided solid particles which form.)

11. Continue to heat the sulfur until it begins to burn.

12. Note the blue flame with which the sulfur burns and carefully observe the resulting odor. Put the hot spoon and hot sulfur into the jar of cold water if at any time things seem to be getting out of control.

13. Do not lay the hot spoon down. Hold the spoon in the flame until the sulfur is burned away. Remove from the flame and allow to cool until the spoon is not hot to the touch. Notice that the spoon is tarnished.

14. Extinguish the alcohol lamp.

15. Compare the stickiness or brittleness of one globule of yellow sulfur in the jar of cold water from step 6 with the drop from the more viscous sulfur from step 9. (Save the other globules of yellow sulfur from step 6 for use in activity #35.)

16. Summarize the results.

No. 35: Forming compounds with copper using heat to speed the reaction

Materials needed:

3 New pennies (shiny)
Sulfur (Globules from activity #34)
Test tube holder
Alcohol lamp
Pencil
Paper

What to do:

Part A.

1. Light the alcohol lamp.
2. Grasp a shiny penny with a test tube holder.
3. Heat the penny. Note that the penny begins to turn color.
4. Continue heating until it begins to become reddish black or a slate gray.
5. Allow the penny to cool. Do not lay it down until it is cool.
6. Observe the reddish black color and the slate gray color. (These are the two oxides of copper.)
7. Explain what evidence there is that there has been a chemical change.

Part B.

1. Heat a second penny until it is hot but not hot enough to form an oxide.
2. Remove from the heat.
3. Drop a globule of sulfur on the hot coin and observe what happens.
4. Allow the coin to cool.
5. Extinguish the alcohol lamp.
6. Write the chemical symbols for copper and sulfur.
7. Explain what chemical change has occurred. Look in a reference, if necessary, to find the name of the compound which was formed.
8. Write the formula for the compound formed.

No. 36: Bleaching with oxygen of the air

Materials needed:

Colored paper (red, blue, yellow, black, green) cut into 2" x 4" strips

What to do:

1. Put one piece of each sample color available into each of two identical piles.

2. Spread one pile of samples on a window ledge in the sun.

3. Spread the other pile of samples on a shelf of a dark cabinet or closet.

4. Wait one week and compare the colors of the upper side of the samples to the lower sides by folding over one corner.

5. Compare the amounts of bleaching between the samples exposed in the sunlight and the samples left in the dark. (The sunlight speeds up the bleaching process. Bleaching is due to a deteriorating chemical reaction of the dye with the oxygen from the air. Some kinds of dyes are more resistant to bleaching than others.)

6. Draw conclusions based on the results.

Note: Sometimes this can be seen when removed material from the bulletin board has been overlapped for some time.

No. 37: Using sodium hypochlorite solution as an oxidizing (bleaching) agent which does not depend on burning

Materials needed:

Sodium hypochlorite solution (Chlorox, Hilex, bleaching powder) (Caution: Great care must be taken to prevent spilling on hands, clothes, table or floor)
Colored samples of cloth and yarn
Bowl
Pencil
Paper
Clock

What to do:

1. Place the samples around the inside of the bowl.

2. Pour enough sodium hypochlorite solution* into the bowl to wet only a part of each sample. Record the time.

3. Observe the samples at 10 minute intervals, recording the time when each sample is bleached.

4. Make a chart listing the fabric, the time when the fabric is put into the bleach solution and the time when the fabric is bleached.

5. Compute the time required to bleach each sample. Compare the bleached portion of the samples with unbleached portions of the samples. (Many fabrics are weakened as well as bleached by strong solutions of sodium hypochlorite. The bleach damages living tissue with prolonged contact. If the solution is splashed or spilled, wash it away immediately and thoroughly with water.)

6. Draw conclusions based on the results.

*Note: Sodium hypochlorite solution deteriorates to produce oxygen which causes the bleaching action.

$$2\ NaClO \longrightarrow 2\ NaCl + O_2$$

No. 38: Becoming aware that air contains substances which may take part in chemical reactions*

What to do:

1. Discuss the chemical reactions which produce the following end results:

   A. Rust on a lawn mower: combination of iron with oxygen (see activity 5).

   B. Sun-bleached hair in summer: more rapid combination of hair pigment with oxygen in sunlight (see activity 33).

   C. Tarnished silverware: combination of silver with sulfur in the air (see activity 42).

   D. Hardened cement: combination of carbon dioxide air with (slaked lime) of cement (see activity 12 and 47).

   E. Clouding of limewater on long exposure to air: combination of limewater with carbon dioxide (see activity 27).

   F. Formation of green coating on copper roof sheathes*: complex reactions of copper with nitrate and sulfate impurities in the air (go and see First Baptist Church steeple, 10th and Harmon Place or the dome of the Basilica of St. Mary, 16th and Hennepin).

   G. Weathered stone and brick buildings: stone or mortar combining with moisture and carbon dioxide (see activity 28).

2. Explain how these effects provide that air is a mixture of gases.

* Beauchamp, Wilbur L., et al. 1957. Discovering Our World, pp. 137-138, Scott, Foresman, Chicago.

No. 39: Proving that burning (rapid oxidation) requires oxygen

Materials needed:

2 Candles, 3"
2 Glass jars, 1 pint jar, 1 quart jar
Water
2 Bowls
Limewater

What to do:

1. Light the candle. Drop a few drops of liquid candle wax in the bottom of a bowl and immediately set a candle in it. Hold the candle upright and stationary until the wax solidifies.
2. Repeat step 1 with the other candle. Extinguish the second candle.
3. Invert the bowl containing the lighted candle over the larger jar so that the candle extends down into the jar.
4. Remove the bowl and candle after 20 seconds.
5. Test immediately for carbon dioxide by pouring 1" of limewater into the jar. Note whether the limewater becomes cloudy.
6. Rinse the jar thoroughly with water.
7. Light the other candle.
8. Add 2" of water to each bowl, being careful not to drown the flame.
9. Invert both jars at the same time over the flame and candle. Lower the jars until they rest on the bottom of the bowls.
10. Observe the candle flames and the water level in the jars.
11. Explain why the candle flame finally goes out. Observe whether both candles go out at the same time.
12. Allow the jars to cool.
13. Measure and estimate what fraction of each jar is filled with water.
14. Explain how the observations indicate oxygen is necessary to burning.
15. Recall the information in step 5. Consult references to learn what gas is most abundant in air. Explain what gas or gases remain in the jar after the candle is extinguished.
16. Draw conclusions based on the results.

No. 40: Discovering that burning produces more than one form of energy

Materials needed:

Candle, 3"
Alcohol lamp
Wood splints
Bowl, small
Match

What to do:

1. Light a match and observe the forms of energy, heat and light, which are produced by the flaming match. Light a second match if necessary.
2. Light the alcohol lamp.
3. Observe the flame of the alcohol lamp. Note the forms of energy produced by the burning alcohol.
4. Use the alcohol lamp to light a wood splint.
5. Note the forms of energy released by the burning wood.
6. Extinguish the wood splint in a jar of water and place it in the waste basket.
7. Use the alcohol lamp to light the candle. Extinguish the alcohol lamp.
8. Drop a few drops of liquid candle wax on the bottom of the bowl and immediately set the candle in it. Hold it upright and stationary until the wax solidifies.
9. Note the forms of energy produced by the burning candle.
10. Extinguish the candle.
11. Make a general statement which relates burning fuels to energy.
12. Identify the fundamental source of the energy stored in fossil fuels. Discuss the change of the sun's energy to fossil fuels to released energy of heat and light.

No. 41: Comparing the kindling temperatures of materials

Materials needed:

Coal
Coal dust
Sawdust
Raw cotton
Cloth (various kinds)
Butter
Sugar
Flour
Ring clamp
Rectangular iron support
Powdered charcoal
Match head
Paper
Zinc metal strip
Alcohol lamp
Pie tin, circular, 4" diameter minimum

What to do:

1. Attach the ring clamp to the rectangular iron support.
2. Place a very small amount of some of the samples in piles around the edge of the pie tin. Be sure each material is the same distance from the center. Caution: Butter melts and runs.
3. Place the pan on the ring clamp with its center over the center of the opening in the ring.
4. Light the alcohol lamp.
5. Heat the center of the pie tin and observe how long the pan is heated before each substance catches fire. Note that some of the materials may not catch fire.
6. Record the data.
7. Repeat steps 2 through 6 until all samples have been tested. Be sure to keep the pie tin the same distance above the alcohol lamp flame.
8. Compare results.
9. Raise the pie tin. Repeat steps 2 through 6 for those materials which catch fire at the same time.
10. Extinguish the alcohol lamp.
11. Draw conclusions regarding the kindling temperatures of different materials.

No. 42: Discovering evidence that some combustible materials may not always burn completely

Materials needed:

Candle, about 3" long
Alcohol lamp
Glass jar
Cool water
Jar lid
Pencil
Paper

What to do:

1. Light the alcohol lamp.
2. Fill the jar with cool water. Wipe the jar dry on the outside.
3. Hold the jar of water over and in the flame and observe the solid material which forms on the jar.
4. Clean the surface of the jar.
5. Extinguish the lamp.
6. Light the candle.
7. Drop a few drops of melted candle wax on the jar lid and set the bottom of the candle on the liquid wax. Hold it upright and stationary until the wax solidifies.
8. Hold the clean jar close to the candle flame and observe the solid material which forms on the jar.
9. Extinguish the candle.
10. Summarize the results and explain what the observations indicate.
11. Write the symbol for the substance formed on the cool jar. Consult references if necessary.

No. 43: Studying the preparation and some properties of oxygen

Materials needed:

Test tube, 6", Pyrex
Hydrogen peroxide (3%)
Manganese dioxide
Wood splint (paste stick)
Burette clamp
Rectangular iron support
Glass jar
Water
Match
Paper
Pencil

What to do:

1. Attach the burette clamp to the iron support and suspend the test tube vertically in the clamp.

2. Fill the test tube to the depth of one inch with 3% solution of hydrogen peroxide.

3. Add a very small amount of manganese dioxide to the tube.

4. Note the bubbles which form and rise through the liquid.

5. Use a match to light the wood splint.

6. Blow out the flame on the splint to obtain a glowing splint.

7. Place the glowing splint into the mouth of the test tube. (Oxygen is the only common gas which causes a glowing splint to burst into flame.)

8. Extinguish the splint in a jar of water and place it in the waste basket.

9. Observe the solution to see if the gas bubbles are colored.

10. Explain what chemical reaction has occurred. Write the symbol for oxygen.

No. 44: Separating water into its parts
Preparing hydrogen and oxygen from water

Materials needed:

2 Test tubes, 6", Pyrex
Cork, to fit test tubes
3 Dry cells, $1\frac{1}{2}$ volt
Acid, hydrochloric *
Electrolysis apparatus, Brownlee form
4 Insulated pieces copper wire,
  2 pieces about 8"
  2 pieces about 18"
Rectangular iron support
Burette clamp
Battery jar or other large glass container
Wood splint
Water, warm
Sandpaper

What to do:

1. Remove one inch of the cloth insulation from each end of the wires. Scrape the varnish insulation off the wire with sandpaper.

2. Connect the three dry cells together in series as follows:

   a. Connect the center pole (+) of the first dry cell to the side pole (-) of the second dry cell with a short length of wire.

   b. Connect the center pole (+) of the second dry cell to the side pole (-) of the third dry cell with a short length of wire.

   c. Connect a longer wire on the side pole (-) of the first cell. Do not connect the other end of this wire until directed.

   d. Connect the second longer wire on the center pole (+) of the third dry cell. Do not connect the other end of this wire until directed.

3. Hang the electrolysis apparatus on the lip of the battery jar.

4. Fill the jar nearly full with warm water or until the platinum electrodes are completely submerged.

* If the acid is spilled, wash it away thoroughly with water followed by a weak solution of baking soda and finally by more water.

5. Place the test tubes in the jar and allow them to fill completely with water. Turn the tubes over and lift them over the tops of the electrodes. Take care to avoid lifting the lips of the test tubes out of the water. (If difficulty arises in getting the test tubes completely full, fill the test tubes with water, cork them tightly, invert them, place them in the water and remove the stopper under water.)

6. Add one or two drops of hydrochloric acid to the water. (Addition of the acid makes the water a better conductor to electricity.)

7. Connect the free end of one of the longer wires to one of the electrodes. Connect the second long wire to the other electrodes.

8. Note whether bubbles appear on the electrodes. Wait for a period of time and note that, as the bubbles rise into the test tubes, the test tubes fill with gas. (The test tubes appear to become empty. The tubes may need to be steadied as they become filled with gas.)

9. Observe the amount of gas in each test tube and explain why the amounts are different.

10. Disconnect the wires which join the electrodes to the dry cells.

11. Lift the test tube containing the lesser amount of gas off of the electrode, taking care to keep the lip of the test tube below the surface of the water. Insert the cork into the tube tightly before the lip of the tube is lifted out of the water.

12. Place the test tube stopper up, in the burette clamp. Remove the cork and test the gas to discover whether an indication of oxygen is obtained by putting a glowing splint into the opening of the test tube.

13. Remove the other tube in the same way the first one was removed.

14. Place this tube in the burette clamp. Light a match. Remove the cork and immediately bring the lighted match to the mouth of the tube. (This is a test for hydrogen.) Observe what happens.

15. Explain how the oxygen and hydrogen are produced.

16. Explain how this activity provides evidence that compounds are often formed from more than one element.

No. 45: Forming compounds with silver

Materials needed:

2 Dimes, new, shiny
Sulfur, flowers of
Tincture of iodine
Alcohol lamp
Test tube holder
Pencil
Paper

What to do:

Part A.

1. Make sure one dime does not come in contact with the sulfur.

2. Rub a small amount of powdered sulfur on the other dime.

3. Allow the coins to stand for two hours.

4. Wipe the sulfur off of the second dime.

5. Compare the dimes.

6. Explain the observable difference.

7. Write the symbols for silver and sulfur.

8. Write the formula for the compound formed. Use a book for this information if necessary.

Part B.

1. Light the alcohol burner.

2. Grasp the shiny dime with the test tube holder.

3. Place a drop of tincture of iodine on the coin.

4. Heat the coin slightly.

5. Write the symbol for iodine.

6. Observe the coin to discover whether a chemical change has occurred. Explain the results.

7. Write the formula for the compound formed. Consult references if necessary.

No. 46: Forming a compound by chemically combining two substances

Examining the properties of Materials before and after chemical reaction (Teacher Demonstration)

Materials needed:

Sulfur, flowers of
Iron filings
Magnet
5 Test tubes, 6", Pyrex
Rectangular iron support
Burette clamp
Alcohol lamp
Mortor and pestle
Teaspoon
Paper
Vinegar
2 Corks, to fit the test tubes
Pencil

What to do:

1. Mix 2 teaspoonfuls of powdered sulfur with one teaspoonful of fine iron filings on a clean piece of paper.

2. Place 2 inches of water in a test tube.

3. Add a small amount of the mixture from step 1 to the water and observe what happens.

4. Place a small amount of the mixture from step 1 on a clean piece of paper. Bring a magnet near the mixture and observe what happens.

5. Place a small amount of the mixture from step 1 in a test tube.

6. Add some vinegar to the mixture. Grasp the test tube with a test tube holder.

7. Heat the test tube slowly to boiling. Allow the liquid to stop boiling and lightly stopper the test tube. Observe what happens. Use care to observe the odor. (Vinegar reacts with iron to form hydrogen gas which is odorless. However, although the quantity of gas formed is usually not great enough to burn, the bubbles formed are quite evident. The odor should be the odor of vinegar.)

8. Place the remainder of the mixture from step 1 in a test tube.

9. Support the test tube vertically in a burette clamp attached to a rectangular iron support.

10. Light the alcohol lamp.

11. Heat the mixture until it has all turned black. (If a liquid petroleum burner is used, the mixture turns bright red with heat. When the heat is removed, observe the continuous heat produced by the chemical reaction occurring in the test tube.)

12. Extinguish the alcohol lamp. Allow the test tube to cool.

13. Retrieve the chunk of black material from the cooled test tube. Use a pencil to loosen the materials. (If the material does not come out of the test tube easily, reheat the test tube. Place the test tube in a jar of cold water to break the glass test tube. Take care not to get cut on the broken glass.)

14. Grind the material in a mortor and pestle.

15. Test the material from the test tube as the mixture from step 1 was tested in steps 2 through 7. (Some of the material is still magnetic indicating an incomplete reaction since it would be non-magnetic if the sulfur and iron are chemically united. Vinegar reacts with iron sulfide to form hydrogen sulfide (rotten egg) gas. This should be evident.)

16. Compare the results of the tests on the mixture made in step 1 and on the chunk of material from step 13. Draw conclusions based on the comparison.

17. Write the symbols for iron and sulfur and the formula of the new compound formed.

No. 47: Observing the pressure exerted by a gas (carbon dioxide) as it forms

Materials needed:

Vinegar
Baking soda
Water
One hole rubber stopper (to fit pop bottle)
Wax paper
Glass tubing, 8" long, 6 mm internal diameter
Dish pan
Pop bottle, 6 or 7 oz. size
Tablespoon
Pencil
Paper

What to do:

1. Push the tubing through the hole in the rubber stopper from bottom to top. Adjust the length of the tubing below the stopper so that it reaches nearly to the bottom of the bottle when the stopper is in place.

2. Pour water into the pop bottle until it is about 2" deep.

3. Add vinegar to the water until there is $\frac{1}{4}$" more liquid in the pop bottle.

4. Place a tablespoon of baking soda on the 3" square piece of wax paper.

5. Roll the baking soda on the paper into a slender cylinder and twist both ends to seal the roll.

6. Place the pop bottle in the dish pan.

7. Drop the roll of baking soda into the pop bottle and immediately close the bottle with the rubber stopper and tube using a slight twisting motion. (If the stopper is inserted too slowly, the fountain will not work properly.)

8. Observe what happens.

9. Explain how the observations indicate the formation of a gas inside the pop bottle.

10. Write the formula for the gas which is formed. Consult a reference if necessary.

11. Explain how this chemical reaction could be used in making a type of fire extinguisher.

12. Summarize the results.

No. 48: Using a chemical reaction to put out a lighted candle

Materials needed:

1 cup	-	Vinegar
½ cup	-	Baking soda (sodium bicarbonate)
1	-	Battery jar, 1 gallon size
1	-	Candle, paraffin, short
1 book	-	Matches
1 block	-	Wood, about 2" x 2" x ½"
1	-	Teaspoon

What to do:

1. Light the candle. Drip a few drops of melted wax on the center of the piece of wood. Place the bottom of the candle in the melted wax and hold it steady in an upright position until the wax solidifies.

2. Pour about one cup of vinegar into the battery jar. Float the lighted candle on the wooden block in the vinegar in the battery jar.

3. Observe the results. Add more soda if necessary.

4. Attempt to relight the candle while it is in the jar.

5. Record the results.

No. 48A: Using a chemical reaction to put out a fire

Materials needed:

1	-	Bottle, glass, wide mouth, 8 oz. size
1 oz.	-	Vinegar
1 tsp.	-	Baking soda (sodium bicarbonate)
1 qt.	-	Water
1	-	Rubber stopper, 1-hole, to fit bottle above
1	-	Medicine dropper, without rubber bulb
6"	-	Sewing thread
1 book	-	Matches
1	-	Medicine vial, small, 1 oz. size
1	-	Teaspoon
1	-	Coffee can, empty, at least 1 lb. size
	-	Scrap or newspaper

What to do:

1. Tie one end of the thread around the upper end of the medicine vial.
2. Fill the vial about 3/4 full of vinegar.
3. Place 3/4 cup of water in the bottle. Add one teaspoon of baking soda.
4. Push the small jet end of the medicine dropper up into the hole in the rubber stopper (from the smaller to the larger diameter surface) so that when the stopper is placed firmly in the bottle, the jet end of the medicine dropper extends beyond the stopper.
5. Take these materials plus the coffee can and the scrap paper with you as you take the class out to the playgrounds on a quiet, non-windy day.
6. Lower the medicine vial of vinegar into the bottle carefully keeping the mouth of the vial above the surface of the water.
7. Insert the stopper to hold the thread and vial in place.
8. Make a small fire from scrap paper in the coffee can on the ground.
9. Turn the bottle over quickly and aim the jet of the medicine dropper at the fire.
10. Observe what happens.
11. Compare the chemical reactions in the two methods of extinguishing a flame in No. 48 and No. 48A. Explain the similarities and differences in the way the flame is extinguished.

No. 49: Converting stored chemical energy into mechanical energy

Materials needed:

Flask, Erlenmeyer, 250 ml, Pyrex
One-hole rubber stopper (#6 or 6½) to fit flask
Glass tubing, 8", 6mm internal diameter
Liquid petroleum burner
Rectangular iron support
Ring clamp
Wire gauze
Burette clamp
Stiff cardboard (not corrugated)
Needle, darning
Cork, large

What to do:

1. By heating the glass tubing over the lighted burner, draw the tubing into a narrow neck about 2" from one end. Allow to cool before it is cut. Cut the tubing to make a narrow tip or jet on the larger piece. Hold the shorter piece of glass in the flame so that the tip end completely seals. Allow to cool. Bend the longer piece of glass tubing at right angles near its center. Allow to cool.

2. Insert the blunt end of the longer piece of tubing through the hole stopper from top to bottom.

3. Support the flask on the wire gauze which is held up by the ring clamp attached to the iron support. Steady the flask with a burette clamp attached to the iron support.

4. Pour water into the flask until it is about 1 inch deep.

5. Insert the stopper into the flask with a twisting motion.

6. Cut a 2" diameter circle from the cardboard. Draw perpendicular diameters on one side of the cardboard. Cut along each radius from the outside edge of the cardboard to within ½" of the center of the circle.

7. Bend one edge of each quarter section up and the adjacent edge of the next quarter down. Continue to bend all quarter sections to make it into a kind of wind mill.

8. Insert the eye end of the needle into the large surface of the large cork stopper so that it sticks straight up.

9. Use a scissors to put a very small hole through the center of the cardboard wind mill. Insert the short length of sealed glass tubing through the center of the wind mill.

10. Place the open end of the glass tubing over the point of the upright needle. (This provides an almost frictionless bearing for the wind mill.)

11. Light the liquid petroleum burner.

12. Heat the water in the flask. Do not heat the water too rapidly since steam pressure can cause the stopper to fly out of the flask and spray hot water about the room.

13. Hold the pinwheel in the jet of steam after the water begins to boil. Observe what happens.

14. Trace the steps in the conversion of chemical energy in the liquid petroleum through the mechanical energy of the steam to the mechanical energy of the turning wind mill.

15. Extinguish the burner.

16. Explain how a device (turbine) operating in this way can be used to provide energy (electric generator) for doing work.

No. 50: Converting chemical energy into electrical energy

Materials needed:

Wire, copper, insulated, No. 22
Magnetic compass
Copper metal strip
Zinc metal strip
Vinegar
Glass jar, (baby food)
Sandpaper, 1" x 1", medium grade
Dry cell

What to do:

1. Wrap a coil of 20 to 30 turns of wire in one direction around the compass.

2. Set the compass on a flat surface. Observe the direction the compass needle points.

3. Turn the compass and coil of wire so that the compass needle and the coil of wire are one under the other.

4. Clean the insulation off both ends of the wire with sandpaper.

5. Connect one end of the wire to each of the terminals on a battery. Observe what happens.

6. Disconnect the ends of the wire from the battery.

7. Pour 3" of vinegar into the glass jar.

8. Attach one end of the wire to the zinc strip and the other end to the copper strip.

9. Place the two metal strips into the vinegar. Be sure they do not touch one another. Observe the compass again to discover whether the compass needle continues to point to the north. (If the north-seeking pole of the compass needle is at right angles to the copper wire coil, it may be necessary to move the compass to detect movement of the needle.)

10. Turn the compass and coils of wire to a new direction. Observe whether the compass needle turns as the coil of wire turns. Note that the compass needle does not always point to the north.

11. Examine the metal strips and the vinegar solution carefully to detect evidence that a chemical reaction is occurring.

12. Remove the metal strips from the vinegar.

13. Explain why this provides evidence that another kind of energy (electrical energy) has been made by the chemical reaction. Consult references if necessary.

No. 51: Observing a chemical reaction used in the building industry

Materials needed:

Lime* (Calcium oxide)
Water
Glass jar
Teaspoon

What to do:

1. Place a teaspoon of lime in the glass jar.

2. Add 4 teaspoonfuls of water. Mix thoroughly.

3. Allow the mixture to stand until the water evaporates.

4. Press on the lime with the pencil. Observe the hardness of the material which remains.

5. Explain how this reaction may be useful in brick and stone-laying and whitewashing. Consult references if necessary.

* Lime is a ~~very~~ dangerous substance and should be handled with great care. If lime comes in contact with the skin, wash it off thoroughly with water.

No. 52: Preparing a useful chemical substance from skim milk

Materials needed:

Milk, skim
Beaker, 250 ml, Pyrex, 2
Wire gauze
Alcohol lamp
Vinegar
Glass rod
Water
Doll dish
Borax
Paper, about 8" x 11"
Jars (baby food), 2
Plate glass, 2 pieces
Cheese cloth bag
Oven mitt
Refrigerator

What to do:

1. Fill the beaker about half full of skim milk.
2. Place the beaker of milk on wire gauze which is resting on the ring clamp attached to the support.
3. Light the alcohol lamp and place it under the beaker.
4. Adjust the height of the ring clamp to place the beaker just above the flame.
5. Heat the milk until nearly boiling. Stir the milk to avoid scorching it.
6. Extinguish the alcohol lamp. Remove the beaker from the wire gauze and place it on a table surface which will not be marred by heat.
7. Stir vigorously while adding vinegar until the beaker is 3/4 full. Observe any change as it occurs.
8. Allow the solid to settle to the bottom of the beaker.
9. Pour off the liquid keeping the flocculent solid (casein) in the beaker.
10. Add cold water to a depth of 2". Stir vigorously with the glass rod. Allow the solid to settle to the bottom of the beaker. Pour off the water through a handkerchief draped over the top of a second beaker keeping the solid in the first beaker.
11. Wash this solid with a number of changes of cold water. Pour the rinse water through the handkerchief each time.

12. Pour the solid and last rinse water into the handkerchief. Squeeze out the water.

13. Place a clean piece of paper which has been creased through the middle on a table. Remove the milk solid from the handkerchief. Rub the milk solid through the wire gauze which is held above the paper. (It may be necessary to cool the solid before the grating is completed.)

14. Pour half of the grated solid into a glass jar.

15. Fill a second jar half full of water. Add borax to the water until some remains in the bottom of the jar after it has been thoroughly stirred.

16. Pour enough of this saturated borax solution onto the grated solid in the jar to make a thin paste.

17. Stir and mix together thoroughly.

18. Use this mixture to glue two small pieces of glass together. Allow the glue to dry over night.

19. Examine the glued pieces of glass to determine the holding quality of the glue.

20. Summarize and record the results.

No. 53: Making a model of the structure of carbon monoxide

Materials needed:

Marshmallows, (colored) large
Toothpicks
Pencil
Paper

What to do:

1. Choose one color of large marshmallows to represent carbon atoms and a second color to represent oxygen atoms.

2. Break a few toothpicks into 3 equal lengths.

3. Join a "carbon atom" to an "oxygen atom" by pushing a piece of toothpick part way into one marshmallow and forcing the other marshmallow onto the other end of the piece of toothpick far enough so that the two "atoms" touch each other.

4. Explain what substance this model represents and write its formula. (Note: The sizes of the atoms are not represented true to size scale with this model molecular. The marshmallow for carbon should be about $1\frac{1}{4}$ times as large as the marshmallow for oxygen. Very accurate representations can be made with a great deal more effort by using styrofoam balls which are sanded to exact scaled dimensions. Construction of models of atoms is much more difficult and probably should not be attempted in this unit.)

No. 54: Studying the structure of carbon dioxide

Materials needed:

Marshmallows, (colored) large
Toothpicks
Pencil
Paper

What to do:

1. Choose one color of large marshmallows to represent carbon atoms and a second color to represent oxygen atoms.

2. Attach two "oxygen atoms" to a "carbon atom" so that the two "oxygen atoms" are on opposite sides of the "carbon atom."

3. Explain what substance this molecular model represents and write its formula. (Note: The sizes of the atoms are not represented true to size scale with this molecular model. The marshmallow for carbon should be about $1\frac{1}{4}$ times as large as the marshmallow for oxygen. Very accurate representations can be made with a great deal more effort by using styrofoam balls which are sanded to exact scaled dimensions. Construction of models of atoms is much more difficult and probably should not be attempted in this unit.)

No. 55: Studying the structure of water

Materials needed:

Marshmallows, (colored) large
Marshmallows, white, small
Toothpicks
Paper
Pencil
Protractor

What to do:

1. Choose one color of large marshmallows to represent oxygen atoms. Represent hydrogen atoms with small, white marshmallows.

2. Use a protractor to construct a 105° angle on a piece of paper.

3. Lay the center of an "oxygen atom" on top of the angle where the two lines meet (vertex).

4. Hold a piece of toothpick over the line which forms one side (legs) of the 105° angle. Push the toothpick into the center of the side of the marshmallow ("oxygen atoms") in the direction of the line. Allow only 1/4" of the toothpick to stick out of the marshmallow.

5. Repeat step 4, pushing a second toothpick into the marshmallow along the other side (leg) of the 105° angle.

6. Push a small white marshmallow onto the exposed end of each toothpick.

7. Explain what molecule this model represents and write its formula. (Note: The sizes of the atoms are not represented true to size scale with this molecular model. If a small marshmallow represents a hydrogen atom, the marshmallow for oxygen should be slightly more than 2 times as large. Very accurate representations can be made with a great deal more effort by using styrofoam balls which are sanded to exact, scaled dimensions. Construction of models of atoms is much more difficult and probably should not be attempted in this unit.)

No. 56: Observing the fact that molecules move

Materials needed:

Watch glass
Perfume or other volatile and odorifirous substance

What to do:

1. Ask each child to remain perfectly still. Close the windows and the door. Eliminate any forced movement of air in the classroom such as a fan or a univent.

2. Instruct the children to raise their hands when they smell the perfume or different odor.

3. Pour a small quantity of perfume into the watch glass.

4. (Note that the children closer to the perfume raise their hands before the children who are farther away.)

5. Explain how the observations provide evidence for the fact that air molecules are always in motion.

No. 57: Observing the results of the movement of molecules and atoms
(Teacher Demonstration)

Materials needed:

Iodine crystal*
Potassium permanganate crystal*
Water
2 Glass jars, about 1 pint capacity

What to do:

1. Fill each jar 1/2 full of water.

2. Allow the water to stand 3 minutes and observe the color of the water.

3. Drop a crystal of potassium permanganate into one jar of water. Do not stir or shake.

4. Drop a crystal of iodine in the second jar of water. Do not stir or shake.

5. Observe the color of both jars of water at 30 minute intervals.

6. Explain how the observations provide evidence for the fact that atoms and molecules are in constant motion. (Iodine crystals are made of iodine molecules. Iodine molecules are made of two atoms of iodine. In this activity iodine is assumed to be an illustration of an atom in motion.)

* Caution: Iodine and potassium permanganate, either as crystals or in solution, produce resistant stains on skin or clothing.

No. 58: Discovering that there are a very large number of molecules in a small amount of material. (Note: This activity is a direct modification of one found on pp. 33-35 in Let's Explore Chemistry by Nathan Feifer.)

Materials needed:

Medicine dropper	Teaspoon
Potassium permanganate	Stirring rod
Water	Measuring cup
2 Glass jars	Paper

What to do:

1. Count the number of teaspoonfuls of water in a full cup of water.

2. Pour a few crystals of potassium permanganate onto a clean, dry piece of paper which has been creased through the middle. (Caution: Potassium permanganate, either as a crystal or a solution, produces a resistant stain on skin and clothing.)

3. Place the potassium permanganate in the glass jar and add 1 cup of water. Stir until all the solid has dissolved.

4. Remove 1 teaspoon of the purple solution and pour it into a second jar.

5. Assume that each teaspoonful of colored solution contains at least one molecule. Explain what is the minimum number of molecules in the original solid.

6. Add 1 cup of water. Stir until thoroughly mixed.

7. Repeat steps 4 and 6 until the color is no longer visible.

8. Calculate the minimum number of molecules in the original amount of potassium permanganate. (The number found in step 5 multiplied by itself as many times as the solution was diluted.)

9. Explain why color throughout a cup of water indicates the presence of more than one molecule in the water.

10. Explain why even the last diluted solution is assumed to contain molecules of potassium permanganate. (The added teaspoonful was colored. If one molecule produced all the color, some part of the last jar of water should still be colored.)

11. Answer the question: Are there many molecules in a small amount of material?

12. Discuss the question: How does the result of this activity provide an explanation for the fact that man has never seen an atom?

VII. SOME SUGGESTED CULMINATING ACTIVITIES

1. Making learning exhibits or charts

<u>What to do:</u>

1. Make an exhibit or chart showing the chemical name and the common name of household chemicals.

2. Make an exhibit or chart showing:

   a. raw materials from which some one substance is processed.

   b. how the substance is processed.

   c. chemical characteristics of the processed material.

   d. uses of the processed material.

3. Make a chart listing some chemical and/or physical properties of a substance. Indicate, beside each property listed, a use which depends on that property. (Water would be an easy substance to use.)

   <u>Example:</u>

   "Water"

Property:	Use:
does not burn	putting out fires
dissolves substances	washing clothing
clear	making a snow scene paper weight
specific gravity of	floating logs as they are moved to the mill

4. Explain why both physical and chemical properties of substances determine its uses.

2. Reporting on the history of chemistry

<u>What to do:</u>

1. Make an oral report on the early history of chemistry.
2. Make an oral report on the history of some limited field of chemistry such as the history of synthetic dyes.
3. Draw conclusions concerning the growth of the chemical industry.

3. Making a collection of various materials

<u>What to do:</u>

1. Make a collection of various materials found in the environment.
2. Classify them as natural or processed chemical substances.
3. Draw conclusions about the contributions of the chemical industry to our environment.

4. Making an organized collection of chemical materials

<u>What to do:</u>

1. Reclassify the collection of materials assembled in the preceding activity as organic or inorganic.
2. Regroup the material again. Sort them into elements and compounds.
3. Draw conclusions about methods of grouping substances for study.

VIII. Bibliography

A. Textbooks

Frasier, George Willard, et al, Singer Science Problems.
1959, Singer, Syracuse.
The section on heat in the chapter "Kinds of Energy" deals with combustion, kindling point, heat as a form of energy and changing the chemical energy of fuels into heat.

Parker, Bertha Morris, Matter, Molecules, and Atoms (Basic Science Education Series).
1960, Row, Peterson, Evanston.
This booklet, although written for seventh grade, has a fifth grade reading level. The booklet contains very good information basic to the unit.

Parker, Bertha Morris, What Things Are Made Of (Basic Science Education Series).
1961, Row, Peterson, Evanston.
This booklet contains information on chemical symbols and simple chemical reactions. The booklet has a fourth grade reading level.

Schneider, Herman and Nina Schneider, Science for Today and Tomorrow.
1955, Heath, Boston.
This text contains an excellent section on chemistry. The part dealing with elements and compounds is especially well written and illustrated.

B. Pupil reference books

Cooper, Elizabeth K., Discovering Chemistry.
1959, Harcourt, Brace, New York.
This is a clearly written and interesting coverage of chemistry. Chemical theory is interwoven with experiments. There is a short but well written description of the most common elements and an excellent section on safety in setting up home laboratories.

Freeman, Ira, All About Chemistry.
1954, Random House, New York.
This book contains a general coverage of the field with emphasis on modern applications of chemistry rather than theory.

Freeman, Mae and Ira, Fun with Chemistry.
1944, Random House, New York.
This book has a simple, clearly written introduction. The emphasis of this book is on interesting demonstrations rather than a logical development of chemistry theory. The photographs are excellent.

Gallant, Roy, Exploring Chemistry.
1958, Doubleday, Garden City.
This book has a beautifully illustrated and well written account of the story of chemistry. The historical treatment is especially good.

Lewellen, John, The Mighty Atom.
1955, Alfred A. Knopf, New York.
This book has one of the best descriptions of atomic structure and the power within the atomic nucleus. Applications of nuclear power are included.

Mullin, Virginia L., Chemistry for Children.
1961, Sterling Publishing Co., New York.
This is a well organized book which suggests many valuable experiences for children. The section describing the balancing of chemical equations is good.

Munch, Theodore W., What is Heat?
1960, Benefic Press, Chicago.
This is a very simple short book explaining the basic concepts of heat and application of these concepts. This book has a low vocabulary level and excellent illustrations.

Posin, Daniel I., What is Chemistry?
1961, Benefic Press, Chicago.
This book has a very fine section dealing with the structure of matter and the periodic table of element. While it is simply written with low vocabulary level, it deals quite extensively with atomic combination and chemical change. This book is very well illustrated.

Reuben, Gabriel H., and Joseph De Stefano, What Is An Atom?
1960, Benefic Press, Chicago.
This is a well written and illustrated book covering the areas of the atomic structure, radiation, energy from fission and fusion, controlling nuclear fission and power from nuclear energy.

C. Teacher reference books

Asimov, Isaac, The Intelligent Man's Guide to Science.
1960, Basic Books, New York
Volume One of this comprehensive popular survey of science has an interesting and well written section on the chemical elements and nuclear particles that will be of great value for teacher background. Volume Two has a section dealing with molecules and synthetics.

Brent, Robert, The Golden Book of Chemistry Experiments.
1960, Golden Press, New York.
This is a well written and illustrated source book of many demonstrations and experiments. It is divided into sections, such as water and gases, acids, bases and salts, non-metals, metals, organic chemistry. The book is especially valuable for its exceptionally clear directions and drawings, and for its section on making apparatus for chemical experiments. Some chemical theory and history is included with each section.

Feifer, Nathan, Let's Explore Chemistry.
1959, Sentinel, New York.
This book contains about 200 experiments or demonstrations grouped under classifications such as "Solving the Mystery of Fire," "Working Wonders with Water," "Experimenting with Clever Carbon," "Neutralizing Chemical Opponents," "We Track Down Clues with a Test Tube." While many of the projects described are more applicable to junior or senior high, a number of the demonstrations may be used in the development of concepts pertaining to the sixth grade level. The instructions are clearly written and the chemical principles well brought out. Some highlights of the historical development of chemistry are included in each section.

Gamow, George, Matter, Earth and Sky.
1958, Prentice Hall, New York.
While the chemical section in this survey book is rather short, there is a very clearly written account of some of the major chemical elements and the basic laws of chemistry. This book also has an excellent section on molecular and atomic theory.

Hutton, Kenneth, Chemistry.
1961, rev. ed., Penguin Books, Baltimore.
This is a popularized yet rather technical chemistry text, containing a description of the chemical elements, composition of molecules, and useful compounds. The diagrams and drawings are poor. There is a good account of the chemistry of foods. There is no material for direct use in a unit, but there is much information for teacher background.

Jaffe, Bernard, Crucibles: The Story of Chemistry.
1957, Premier Books, New York.
This is a fascinating story of chemistry from the middle ages to the present. The emphasis is primarily historical rather than systematic account of chemical science.

Krauskopf, Konrad, Fundamentals of Physical Science.
1959, III Edition, McGraw Hill, New York.
This is a college text of physical science with a fairly comprehensive and technical account of chemical structure and processes. It has a good section on chemical reactions that may provide excellent teacher background for elementary school chemistry.

Lessing, Lawrence P., Understanding Chemistry.
1959, Mentor Books, New York.
This book contains a short but interesting description of the basic structure and relationship of chemical elements. The main emphasis is on industrial chemistry and synthetic materials.

D. Instructional motion picture films*

Explaining Matter: Molecules in Motion

EBF, 1959; 11 min.

Explaining Matter: Atoms and Molecules

EBF, 1958; 14 min.

Explaining Matter: Chemical Change

EBF, 1960; 12 min., color

Simple Changes in Matter

Coronet, 1953; 11 min.

The World of Molecules

Churchill-Wexler, 1959; 11 min.

* Refer to pages 3 - 5 in the "Partial Listing of Presently Owned Science Motion Picture Films for Grade Six" to find a description of the content of these films.

IX. SUMMARY LIST OF SUGGESTED EQUIPMENT AND SUPPLIES

acid, hydrochloric (10%)
alcohol, denatured
alcohol lamp
asbestos mat
asbestos sheet
ashes, wood or paper

baking powder
baking soda
beaker, 400 ml, Pyrex
bottle, ink
bottle, pop
bowl
bread
burette clamp
butter

candle
cap for narrow necked bottle
cardboard, stiff, (not corrugated)
cellophane
cells, dry
cement, portland
chalk
clock
cloth, colored sample
cloth, cotton, 4" x 4"
cloth, nylon, 4" x 4"
cloth, various kinds
cloth, wool, 4" x 4"
coal, dust
coal, powdered
coffee can, 1/2# size
copper metal strip
cork, or rubber stopper, with hole, a size to fit the glass, etc.
cotton batting
cotton, raw
cream of tartar
crushed ice

dimes, new, shiny

electrolysis apparatus, Brownlee form
Epsom salt

fertilizer, liquid
flask, Erlenmeyer, Pyrex
flask, Florence, Pyrex
flour
foil, aluminum

glass bottle with top
glass, clean, drinking
glass cutter
glass rod
glass tubing (soft or lime)
glass, watch
graph paper
glycerine

hair
hammer
hardware cloth
Hilex
hydrogen peroxide (3%)

ice
iodine, crystal
iodine, tincture of
iron filings

jar, baby food
jar, battery
jar, glass
jar, glass, 1 pint
jar, glass, 1 quart
jar, glass, wide mouth, 1 gallon size
jar, lid
jar, or can of water

lemon juice
lime
limestone
limewater
liquid chemical in container
liquid petroleum burner
litmus paper

magnet
magnetic compass
magnifying glass
manganese dioxide
marble chips
marshmallows, colored, large
marshmallows, white, small
matches
measuring cup
medicine dropper
medicine vial, small
milk carton
mortor and pestle
mouse, white

nail
needle, darning
nuts, walnut, peanut, almond

oven mitt

pan, dish
paper
paper, colored
paper, hand towel
paper, nut cup
paper, onion skin
paper, wax
pencil
pennies, 3, new
perfume
photographic hypo (sodium thiosulphate)
pie tin, circular, 4" diameter minimum
plants, geranium or coleus, 4
plaster of Paris
plastic, sheet
potassium chlorate
potassium permanganate crystal
protractor

receiving container
rectangular iron support
ring clamp
rubber stopper, one holed, size #1
rubber stopper, two holed (#6 or #6½)
rubber tubing, about 3' long
ruler
ruler, plastic

salt
sand
sandpaper
saw
sawdust
scissors
shoe lace, leather
soap
soap powder
sodium hypochlorite solution
steel wool
stirring rod
straw, sipper
sugar, cane or beet
sugar, cubes, 3
sulfur, flowers of, or roll
solid chemicals in containers
(jar, bottle, carton)

tablespoon
teaspoon, 2, clean
test tube
test tubes, 6", Pyrex
test tube holder
test tube rack
thermometer, Celsius or Fahrenheit
thermos bottle, wide mouth
thistle tube
thread
tin snips
tongs
toothpicks
towel, cloth
triangular file

vinegar

wastebasket or waste can
watch glass
water, distilled
wick, (thickly, loosely twisted
string)
window glass
wing top
wire, copper
wire gauze
wire gauze with asbestos center
wood
wood block
wood shavings
wood splint

yarn, colored sample

zinc metal strip

Some of the chemicals needed for this unit may be obtained with the regular (Form 1000) school requisition. Many of the chemicals used are common household chemicals that can be obtained at grocery or drug stores. Replacement for hobby chemistry sets which may be obtained at department or hobby stores are another potential source of chemicals. The George T. Walker & Co., Inc., 2218 University Avenue S. E., Minneapolis, Minnesota, is a supply house to which the teacher may go to for other chemicals. The procedure as outlined on the "Basic Science Supplies for Elementary Schools" list for preparing a requisition for reimbursement should be discussed with the principal before any purchases are made.

X. TABULATION TO SHOW WHICH ACTIVITIES CONTRIBUTE TO THE UNDERSTANDING OF THE ASSIGNED CONCEPTS

ACTIVITY \ CONCEPT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																	+	
2											+	+						
3											+	+						+
4											+	+						
5											+	+						
6				-							+	+	+	-				
7				-							+	+	+	-				
8			-	-							+	+	+					
9		-	-	+							-							
10		-	-	-							+	+	+					
11		-		-														+
12																		+
13																		+
14																		+
15	+	-	-	-									-	+				

+ contributes directly
- contributes less directly

CONCEPT / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
16	+		-	-									-	+				
17	-			-									-	-				
18				-									+					
19				-						+			+					
20				-					+	+			+					
21				-			+			-			+					
22											+	+						+
23				-									+					
24				-									+					
25		-	-	-														
26		-	-	-														
27		-	-	-	+													
28		-		-														
29				-									+					
30		-	-										+					

+ contributes directly
- contributes less directly

ACTIVITY \ CONCEPT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
31		-	-	-									+					
32		-	-	-									+					
33		-	+	-									+					
34				-			+	+			+	+		-				+
35				-			+	+	+				+					
36				-														
37			-	-														
38		-	-	-									-					
39		-	-	-										-				
40	+		-	-										+				
41		-		-														
42				-									-	-				
43				-									+					
44				-						+	+		+					
45		-	-	-			+	+					+					

\+ contributes directly
\- contributes less directly

CONCEPT / ACTIVITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
46	-			-			+	+					*					
47	+												-					
48	+																	
48A	+																	
49	+																	
50	+	-	-	-										+				
51			-	-									+					
52		-	-	-									+					
53								+	+									
54								+	+									
55								+	+									
56																+		
57															-	+		
58						+		-										

* contributes directly
- contributes less directly

CONCEPT / ACTIVITY	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1																		
2																		
3																		
4																		
5																		
6						-	-					-		-				
7						-	-					-		-		-		
8						-				-	-							
9																		
10																		
11	+	+																
12	+	+																
13	+	+																
14	+	+																
15																		

+ contributes directly
- contributes less directly

CONCEPT / ACTIVITY	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
16																		
17						-	-					-	-			+		
18						+	-			-	+					+		
19																		+
20																		
21																		
22	+	+																+
23														+			-	
24																		+
25															+			
26															+			
27																		
28													+					
29							-	-			-						+	
30																		

+ contributes directly
- contributes less directly

CONCEPTS / ACTIVITY	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
31																		
32																		
33																		
34	+	+																
35																		+
36						+				+	+							
37											+							
38			+															
39			+	-		-	-	+	-	-		+						
40						-	-		+			+						
41															+			
42							-		-			-		+				+
43						+												+
44																		
45																		+

\+ contributes directly
\- contributes less directly

CONCEPT / ACTIVITY	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
46																		+
47																		+
48																		+
48A																		+
49									+									
50																		
51																		
52																		
53																		+
54																		+
55																		+
56																		
57																		
58																		